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July 3, 2003

Mr. Nabil S. Fayoumi
U. S. Environmental Protection Agency - Region 5
Superfund Division
77 West Jackson Boulevard (SR-6J)
Chicago, Illinois 60604-3590

**Re: Remedial Design/Remedial Action Workplan, Final Design Submittal
and Construction Quality Assurance Plan
Groundwater Migration Control System
Sauget Area 2 Superfund Site**

Dear Mr. Fayoumi:

This letter is in response to your e-mail message of June 19, 2003 requiring support documentation for the Administrative Record of the Explanation of Significant Difference (ESD) which EPA intends to issue in the near future.

Enclosed with this letter are the Remedial Design/Remedial Action Workplan, the Final Design Submittal and the Construction Quality Assurance Plan.

The "Amended Focused Feasibility Study, Interim Groundwater Remedy Sauget Area 2 Sites O, Q, R and S" is being submitted under separate cover.

Please note that in the RD/RA Workplan paragraph "3.4 Schedule", that we recommend the barrier wall construction be delayed until spring 2004 to avoid the winter construction season. Data from the Midwestern Regional Climate Center (MRCC) is presented in support of the recommendation. Should EPA not find this acceptable, we will be prepared to begin construction in September per the RD/RA Workplan schedule assuming that the selected contractor can begin mobilization in early August... The proposed schedule is 8 months from mobilization to construction completion. If the wall is constructed through the winter season it may require more time, depending on actual weather conditions.

Please call me at 314-674-6768 if you have any questions.

Sincerely,


Gary W. Vandiver
Project Coordinator

June 9, 2003

cc: Sandra Bron - IEPA
Linda Tape - Husch & Eppenberger
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18 03-1

**GROUNDWATER MIGRATION
CONTROL SYSTEM
SAUGET AREA 2
SUPERFUND SITE**

**Volume 1
Final Design Submittal**

Prepared for
Solutia Inc.
575 Maryville Centre Drive
St. Louis, MO 63141

July 3, 2003

URS

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SECTION ONE

Introduction

On October 3, 2002, an Administrative Order for Remedial Design and Interim Remedial Action (the Order) associated with the Sauget Area 2 groundwater operable unit (the OU) was sent by the United States Environmental Protection Agency (USEPA) to a list of potentially responsible parties (PRPs) for the Sauget Area 2 Superfund Site (the Site). The Order (Docket No. V-W-'02-C-716) directed respondents to perform a remedial design for the Interim Groundwater Remedy described in the associated Statement of Work (SOW) and the Record of Decision (ROD) dated September 30, 2002, and to implement the design by performing an interim remedial action. This document represents the Final Design submittal required by the Order. At the time of submission of this Final Design, Solutia does not know whether any other recipients of the Order intend to comply with the terms of that Order.

1.1 OVERVIEW OF DESIGN

This Final Design submittal has been developed in accordance with the previously submitted Remedial Design/Remedial Action Workplan (RD/RA Workplan) as required by the Order, and is consistent with the design criteria and assumptions established in the Order as well as within the Statement of Work and the Record of Decision associated with the Order.

The remedial action objectives for this work, as stated in the RD/RA Workplan, include:

- Prevent or abate actual or potential exposure to nearby human populations (including workers), animals or the food chain from hazardous substances, pollutants or contaminants
- Prevent or abate actual or potential contamination of drinking water supplies and ecosystems
- Achieve acceptable chemical-specific contaminant levels, or range of levels, for all applicable exposure routes
- Mitigate or abate other situations or factors that may pose threats to public health, welfare or the environment
- Mitigate or abate the discharge of groundwater to the Mississippi River so that the impact is insignificant or acceptable.

SECTION ONE

Introduction

To accomplish these objectives, the selected remedy is a Groundwater Migration Control System (GMCS) that is the subject of this Final Design submittal. Key elements of the GMCS include:

- Institutional controls
- Groundwater recovery wells
- Treatment and discharge of extracted groundwater
- Groundwater quality monitoring, groundwater level monitoring, and sediment and surface water monitoring.
- Installation of a 3,300-ft long U-shaped, barrier wall to be installed between the downgradient boundary of Sauget Area 2 Site R and the Mississippi River

Detailed descriptions of the elements of the selected remedy (i.e., extraction wells, monitoring program, barrier wall, etc.) can be found in Section 2 of the RD/RA Workplan.

1.1.1 Cleanup Objectives

Mass loading, gradient control, and reduction in fish tissue bioaccumulation will be used as performance measures for the Groundwater OU remedial action. Specific descriptions of the cleanup verification methods (Monitoring Programs) to be employed for this Remedial Action are described in detail in Section 2 of the RD/RA Workplan. Groundwater quality monitoring will be conducted on a quarterly basis during the first year of operations of the system; sediment and surface water quality monitoring will be conducted twice a year, during the summer low flow period and the winter low flow period during the first year. These monitoring programs are discussed in greater detail in the Field Sampling Plan which is an element of Volume 3 – Performance Standard Verification Plan, and will be conducted until the final groundwater remedy and associated groundwater monitoring program for the Sauget Area 2 sites is in place.

Extracted groundwater will be discharged to the American Bottoms Regional Treatment Facility for treatment and eventual discharge to the Mississippi River through American Bottoms' diffuser located at the north end of Site R. As such, the treated groundwater will be in compliance with all Applicable or Relevant and Appropriate Requirements (ARARs).

SECTION ONE

Introduction

1.1.2 Design Flow Rates

The design criteria and assumptions utilized to determine the flow rates from the groundwater extraction wells were developed and previously submitted in the Focused Feasibility Study developed for the Sauget Area 2 groundwater operable unit. Sections 3, 4, 5, and 6 of this document present additional details concerning the extraction wells, the barrier wall, conveyance system, and control systems, respectively.

1.2 SITING CRITERIA

The various elements of the remedial action have been located based on a variety of factors, including minimization of groundwater flow to the river, subsurface obstructions, access to utilities, and site topography. Several of the key aspects of the project are discussed below. Section 2 presents a more detailed discussion of the design specifics associated with site development for each of these elements.

1.2.1 Extraction Wells

The primary control mechanism for the Groundwater Migration Control System will be the extraction wells. These wells have been sized and located to minimize groundwater discharge to the Mississippi River and to maintain a near zero gradient across the barrier wall.

1.2.2 Barrier Wall

As stated above, the primary control mechanism for this system will be the extraction wells. The role of the barrier wall will be to minimize the flow of groundwater from the west, in the vicinity of the Mississippi River towards the extraction wells. The barrier wall alignment has been selected to optimize performance of the extraction wells within the physical constraints in the vicinity of Site R. Specifically, these constraints include the capped landfill area, the presence of numerous subsurface obstructions in the northwest corner of the site (pipes, tank foundations, etc.) and significant buried utilities along the northern end of the site. The temporary stockpile area, for the temporary storage of spoils generated during wall construction, was selected based upon access to the barrier wall construction activities, as well as the utilization of the clay cap material and topographic features of Site R.

SECTION ONE

Introduction

1.2.3 Effluent Lines

The location of effluent discharge lines that will be used to convey extracted groundwater from the site to an access point in the American Bottoms system has been selected based upon proximity to the American Bottoms system as well as proximity to an existing conduit beneath the U.S Army Corps of Engineers levee immediately east of Site Q.

1.3 REAL ESTATE, EASEMENT, AND PERMIT REQUIREMENTS

All activities associated with the remedial action will be conducted in accordance with specific property access agreements and easements where appropriate (i.e., where Solutia does not own the property). Such agreements and/or easements will be secured prior to initiation of activity on the affected property.

As stated in the Order, no permit is required for any portion of the work conducted entirely on-site, except as provided in 121(e) of CERCLA and the NCP. Where any portion of the work requires a Federal or State permit, timely applications will be made to obtain such permits. A listing of all such permits, if applicable, will be generated following approval of the Final Design submittal.

1.4 SURFACE WATER AND EROSION CONTROL

Prior to construction, the selected contractor will be required to develop and submit to Solutia a Stormwater Management Plan, documenting all measures to be taken to control erosion and collect and manage stormwater during the remedial action. The Construction Manager and contractor Site Superintendent will monitor adherence to this plan on a daily basis.

1.5 PRELIMINARY CONSTRUCTION SCHEDULE

A preliminary construction schedule was previously included in the RD/RA Workplan. This schedule will be periodically updated throughout the duration of the remedial action process.

1.6 CONTRACTING STRATEGY

Solutia, or the PRP Group that includes Solutia, will manage all aspects of the RD/RA process for the Groundwater OU at the Site. An overall Project Manager will be identified who will be responsible for the execution of the RD/RA work in accordance with the Order, the SOW, and

SECTION ONE

Introduction

the ROD. Additionally, a Construction Manager will be identified and assigned to the RD/RA project to assist the Project Manager and to oversee all aspects of the construction program.

A list of pre-qualified bidders will be solicited to prepare bids for the remedial action portion of the project. Based on the submittals received, one or more contractors will be selected to undertake the required remedial actions. This work will then be conducted under the direction of the Construction Manager and in accordance with the Order, the SOW, and the ROD. A Contractor pre-qualification package has been distributed to about ten potential contractors. The responses to that Request for Qualifications will be used to prepare a short list of qualified contractors who can be invited to submit construction bids on short notice.

1.7 ORGANIZATION OF THIS VOLUME

This volume includes a narrative of the design of the GMCS along with supporting drawings, specifications, and calculations. Additional components of the Final Design Package include the Construction Quality Assurance Plan, the Performance Standard Verification Plan, and the Contingency Plan, each of which are presented in additional volumes.

SECTION TWO

Site Development

This section discusses the issues that **determine** the horizontal locations of the barrier wall and the temporary spoil stockpile. Other sections discuss the locations of the extraction wells and the discharge pipeline.

The entire site is located within the 100-year floodplain of the Mississippi River. The approximate 100-year flood elevation is 425. In the area of the barrier wall, the ground elevation varies from 420 to 426. However, the crest elevation of the existing Site R landfill area is above the 100-year flood level.

2.1 BARRIER WALL

The barrier wall will be an approximately 3,300-ft long U-shaped wall between the downgradient boundary of Site R and the Mississippi River. Approximately 2,000 ft of this wall runs parallel to the river bank and two arms (approximately 650-ft long) extend on the north and south sides of the Site R (refer to drawings).

Historical documents, including photographs and site plans, were used to augment a current site plan. Several site visits were conducted to investigate the physical constraints affecting the location of the wall. These constraints included the location of existing fences, pavement, utilities, buildings, and remains of old tank foundations, an abandoned Ranney well, an old sheet pile wall and other subsurface features that would adversely affect wall construction.

The final location of the wall was selected to avoid as many of the surface and subsurface obstacles as possible and provide adequate room to move equipment, materials, and personnel during construction of the wall. The location is outside of the known boundaries of the Site R landfill area.

On the west side, the wall will be located approximately 25 to 30 ft from an existing fence that forms the boundary of the site at the top of the riverbank. This location allows for construction-related equipment to move between the wall and the fence. It also provides for an area on the east side of the wall for excavation of slurry pits to handle spoils that will be generated during wall construction.

The north arm of the wall will be located in the pavement of Riverview Avenue. A fence separates the south side of the road from the north edge of the landfill. North of the road are

SECTION TWO

Site Development

several utilities including a buried water line, buried chemical lines, several sewer lines, and aboveground electrical power lines. A large drainage ditch also lies just north of the road. An overhead line on the south side of the road appears to be a telephone line. Electrical power lines cross the road at several points. The south half of the pavement was selected for the location of the wall because: 1) this location limits the number of overhead electrical power and phone lines that have to be relocated; 2) it is away from the buried utilities; and 3) presents a shorter distance with fewer obstructions for supply of the barrier wall material from a centrally located batch plant. The wall will extend eastward to the existing gate that defines the eastern extent of the landfill.

The south arm of the wall will be located 10 ft south of the fence that defines the south side of the landfill. This property is not under the direct ownership and control of Solutia, and is currently used for the movement of large trucks in and around an existing industrial building. This location was selected to minimize the impact of the wall on the off-site commercial operations. The wall will extend eastward to the end of the fence that defines the eastern extent of the landfill.

Construction of both the north and south arms of the barrier wall will be conducted in areas that do not have room for excavation of slurry pits to contain the spoils. In these areas, the contractor will be required to propose a method of drying and transporting the excavated spoils before placement into the temporary stockpile.

Construction of the barrier wall will require a batch plant for mixing of the slurry. One of the most likely locations for the batch plant is near the west center of the existing site west of the landfill. The area required is estimated to be approximately 50 by 150 ft. Deliveries to the batch plant will be by tractor-trailers and is expected to be in the range of six to ten trucks per day.

2.1.1 Temporary Stockpile

A temporary spoil stockpile will be constructed on the existing landfill to manage the spoils generated during construction. The stockpile will be located at a distance from the top of the slope that defines the landfill so that equipment and delivery trucks will have adequate room to maneuver. Section 3 of this volume provides more information on spoils handling.

SECTION TWO

Site Development

2.1.2 Chain Link Fences

Portions of existing chain link fences will need to be removed to allow wall construction. They may or may not be replaced in the same location. Additional fencing may be required to protect certain new construction such as the extraction wells.

2.1.3 Site Access

The only current access to the site is via the vacated Riverview Avenue on the north side of the landfill. During construction of the wall in this location, this access will be blocked. All construction work regarding the wall installation will be done on property owned by Parties bound by the September 30, 2002 Order; so no access agreements are necessary for the installation work under the Order.

Upon completion of all construction activities, access to the site will be required for purposes of monitoring the operation of the extraction pumping system. Riverview Avenue will provide the access.

2.1.4 Roads On-Site

During construction, the contractor will provide temporary gravel construction roads on-site. These roads are expected to be necessary for the barrier wall batch plant, access roads and parking for workers and material storage, transfer of spoils from the construction area to the temporary spoils stockpile, and general movement of equipment around the site.

New permanent roads will not be required.

2.1.5 Stormwater

Current regulations specify that construction sites of this size provide stormwater pollution prevention plans. Due to the nature of the materials being handled on-site, special provisions for managing stormwater will be required. A Stormwater Pollution Prevention Plan (SWPPP) that meets the requirements of the National Pollutant Discharge Elimination System (NPDES) and State of Illinois regulations will be prepared by the contractor and submitted to Solutia for approval prior to starting any activities. This process will involve implementing best management practices (BMPs) for stormwater runoff that does not contact construction spoils.

SECTION TWO

Site Development

All stormwater that comes into contact with excavated spoil, either in the spoil stockpile or along the barrier wall alignment, will be collected and pumped to an on-site temporary storage tank. The stored water will then be treated on-site using a filter bed and granular activated carbon columns. The treated effluent will be discharged to the existing on-site surface water drainage system. Details of the treatment system will be submitted to EPA for review prior to the start of construction. Run-on of stormwater from off-site will be prevented. Upon completion of the project, natural drainage will be restored.

2.1.6 Agreements for Construction on Public and Private Property

Solutia is in the process of negotiating acquisition of suitable agreements for construction activities on public and private property.

2.2 ELECTRICAL POWER AND TELEPHONE

Primary electrical power (480 volt, 3 phase) and telephone service is available to the site on overhead lines at Riverview Avenue.

As part of construction, electrical power will be provided to the various pumps and other equipment. Permanent facilities will be located on poles or platforms above the 100-year flood level.

2.3 UTILITIES

Since the site will generally be unmanned, no permanent sanitary facilities for workers will be provided.

SECTION THREE

Extraction Wells

The primary control mechanism for the overall Groundwater Mitigation Control System will be the extraction wells. The extraction system consists of three extraction wells located east of the barrier wall. These wells will be drilled in accordance with the Technical Specifications (Numbers 02525, 02526, 16500, and 16900) presented in this volume. Well locations and details are shown in the Drawings.

3.1 DESIGN ASSUMPTIONS AND PARAMETERS

The Specifications were produced based on the following assumptions and parameters:

- The extraction system is to consist of one 10-in. diameter and two 12-in. diameter wells.
- The wells are to be screened with either 65 ft of screen at depths from 40 to 105 ft below ground surface (bgs) (Well EW-2) or 95 ft of screen at depths from 40 to 145 bgs (Wells EW-1 and EW-3).
- Each well is to have a nominal pumping capacity of 667 gallons per minute (gpm). Therefore, the total nominal system capacity will be 2,000 gpm. Actual extraction rates will be determined after the system is installed.
- The overall hydraulic conductivity of the formation is assumed to be 0.1 centimeters per second (cm/sec).
- Extracted groundwater is to be conveyed from the wells via buried underground lines consisting of high density polyethylene (HDPE) pipe.
- On the east side of the levee an existing pipe with a diameter of 30 in. will be used as a casing pipe for the effluent pipeline which will convey the extracted groundwater through certain features and facilities, including a levee and railroad tracks. The pipeline on the west side of the levee will likely be installed in a newly excavated trench. However, this information is pending final construction of the conveyance system.
- The well controls will be placed at each well head.
- Instantaneous flow will be measured at each well (no remote data transmission).
- Total and instantaneous flow will be measured at the discharge point.
- A double-valved sample port will be added to each wellhead.

SECTION THREE

Extraction Wells

- All electrical power will be run underground.
- The piping system will be over-designed in the event that additional flow is required subsequently, using higher capacity pumps.
- The well head will be capable of surviving a 100-year flood event (see below).
- Assume that the system will operate for 30 years.
- Supplied electrical service will be 480 volt, 280 amp service located near the pole-barn.
- The preferred drilling method is to drive 10- or 12-in. diameter casing using a cable tool-drilling rig and install a telescoping screen beneath the casing.

Sieve analyses and boring logs were provided for a number of wells located in the vicinity of the planned extraction wells. Results of the sieve analyses for two of the wells, which are located near the planned extractions wells, are included in Attachment 4-1 of this report. These sieve analyses were used as the design basis for the extraction wells. Sieve analysis depth intervals generally correspond to the depth range of the proposed wells, but do not correspond to the uppermost and lowermost depths.

The extraction wells will be designed to withstand a 100-year flood event to the extent possible and the control panels will be sealed to restrict the influx of floodwater. The control panels will be installed at an elevation above the 100-year flood event.

The extraction system discussed herein has been designed to operate for a 30 year period of time. However, this assumes that periodic maintenance will be conducted. The required maintenance program will be documented in the Operation and Maintenance Plan to be developed for this project.

3.2 TECHNICAL SPECIFICATIONS

Specific design parameters for the wells are discussed in the specifications. The specifications discuss the construction methods, design materials, and design restrictions. Means of handling drill cuttings and fluids and are also discussed in the specifications. The extraction system is illustrated through the use of technical drawings that are included in the specifications. Well performance criteria are discussed in the Construction Quality Assurance Plan.

SECTION THREE

Extraction Wells

Attachment 3-1 Calculations



**Golder
Associates**
CONSULTING
ENGINEERS

SUBJECT SITE R WELLS

Job No. 013-9665

Ref. SCREEN DESIGN

Made by JRS

Checked MSA

Reviewed hnt

Date 3/26/02

Sheet 1 of 5

WELL DESIGN

BASIS OF DESIGN:

CONVERSATIONS WITH SOLUTIA - 3/24/02 TO

3/26/02 + A FAX MESSAGE DATED 3/24/02

WELLS TO BE SCREENED FROM 355' TO 315'

(SURFACE IS APPROXIMATELY 420')

WELL ASSUMED TO HAVE 40' OF SCREEN

INTERMS OF DEPTH BELOW GROUND SURFACE →
SCREEN INTERVAL 65' BGS - 105' BGS

(SCREEN MIDPOINT = 85' BGS)

CAPACITY:

300 GPM WITH 20% OVER DESIGN CAPACITY

FOR A PER WELL CAPACITY OF 360 GPM

(1 GPM = 5.45 M³/DAY)

WELL DIAMETER: 10" WELL WITH 10" DIA

TELESCOPING SCREEN

HYDRAULIC CONDUCTIVITY: ASSUMED TO BE

0.1 CM/SEC



Golder Associates
CONSULTING
ENGINEERS

SUBJECT SITE 2 WELLS

Job No. 013-9665

Ref. SCREEN DESIGN

Made by JRS
Checked MSL
Reviewed WLS

Date 3/26/02
Sheet 2 of 5

CONVERT 510 AS 0.1 CM/SEC = 86 M/DAY

284 FT/DAY

SCREEN ENTRANCE VELOCITY CRITERIA

SOURCE: "THE HANDBOOK OF GROUNDWATER ENGINEERING",
TACQUES BELLEUR, 1999,
CRC PRESS LLC

RECOMMENDED SCREEN ENTRANCE VELOCITY PER
TABLE 9.8:

0.02 M/SEC

ASSUMING 6 HYDRAULIC CONDUCTIVITY OF 86 M/DAY

FORMULA:

$A_0 = \text{EFFECTIVE OPEN AREA PER METER OF SCREEN LENGTH}$

$A_0 = 3.14 \times \text{WELL DIAMETER (m)} \times \text{CLOG FACTOR} \times \text{OPEN AREA}$

$L_m = \text{MINIMUM PERMISSIBLE SCREEN LENGTH}$

$L_m = \text{PUMP RATE (m}^3/\text{DAY)}$

$86400 \times \text{SCREEN ENTRANCE VELOCITY} \times A_0$

($L_m = 3.28'$)



**Golder
Associates**
CONSULTING
ENGINEERS

SUBJECT

SITE R WELLS

Job No.

013-9605

Made by

JRS

Checked

MSL

Ref.

SCREEN DESIGN

Reviewed

MS

Date 3/26/02

Sheet 3 of 5

FORMULA INPUT: WELL DIAMETER = 10" = 0.25 M

CLOG FACIOR = 0.5 (ASSUMED)

SCREEN ENTRANCE CRITERIA = 0.02 M/S

SCREEN OPEN AREAS FOR VARIOUS SLOT SIZES

SOURCE: TECHNICAL SPECIFICATIONS - JOHNSON SCREENS,
TYPE 304 STAINLESS STEEL SCREENS,
TELESCOPING SCREEN, 10" DIAMETER,

OPEN AREA = SLOT

SLOT X WIRE WIDTH

30 SLOT - 0.21

40 SLOT - 0.26

50 SLOT - 0.30

FORMULA APPLICATION - MINIMUM SCREEN LENGTH

30 SLOT = 44' 13.6 M

40 SLOT = 36' 11.0 M

50 SLOT = 31' 9.5 M

RESULTS: NO SLOT AND HIGHER ARE PERMISSIBLE
ACCORDING TO ENTRANCE VELOCITIES



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Sheet 4 of 5

SLOT SIZE BASED ON FORMATION DATA

SOURCES:

- 1) CRITERIA LISTED IN "GROUNDWATER MANUAL", U.S. DEPARTMENT OF THE INTERIOR, 1985
- 2) SIEVE ANALYSES PROVIDED IN "KRUMMREICH GROUNDWATER MIGRATION CONTROL PREDESIGN INVESTIGATION", UNCS, OCTOBER 4, 2001

SIEVE ANALYSIS CURVES FOR SB-2 84'-86'

(CHOSEN TO CORRESPOND TO MID-POINT ON THE PROPOSED SCREEN AT 85' BGS.)

UNIFORMITY - DEPARTMENT OF INTERIOR METHOD

$$\text{PERCENT PASSING} - \text{UNIFORMITY} = D_{60}/D_{10}$$

$$\begin{aligned} D_{60} &= 2.6 \text{ mm} \\ D_{10} &= 0.3 \text{ mm} \end{aligned}$$

$$\text{UNIFORMITY} = 8.67$$

FOR UNIFORMITY OF 8.67 - RECOMMENDED SLOT
SIZE TO RETAIN 30 TO 50% OF AQUIFER
IN OTHER WORDS - ALLOW TO PASS 70% TO 50%
OF AQUIFER



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Reviewed MJS

Sheet 5 of 5

BASED ON PARTICLE SIZE CURVES

50 % PASS = 1.3MM = 0.05 INCH OR

50 SLOT OR HIGHER IS OK

RESULT:

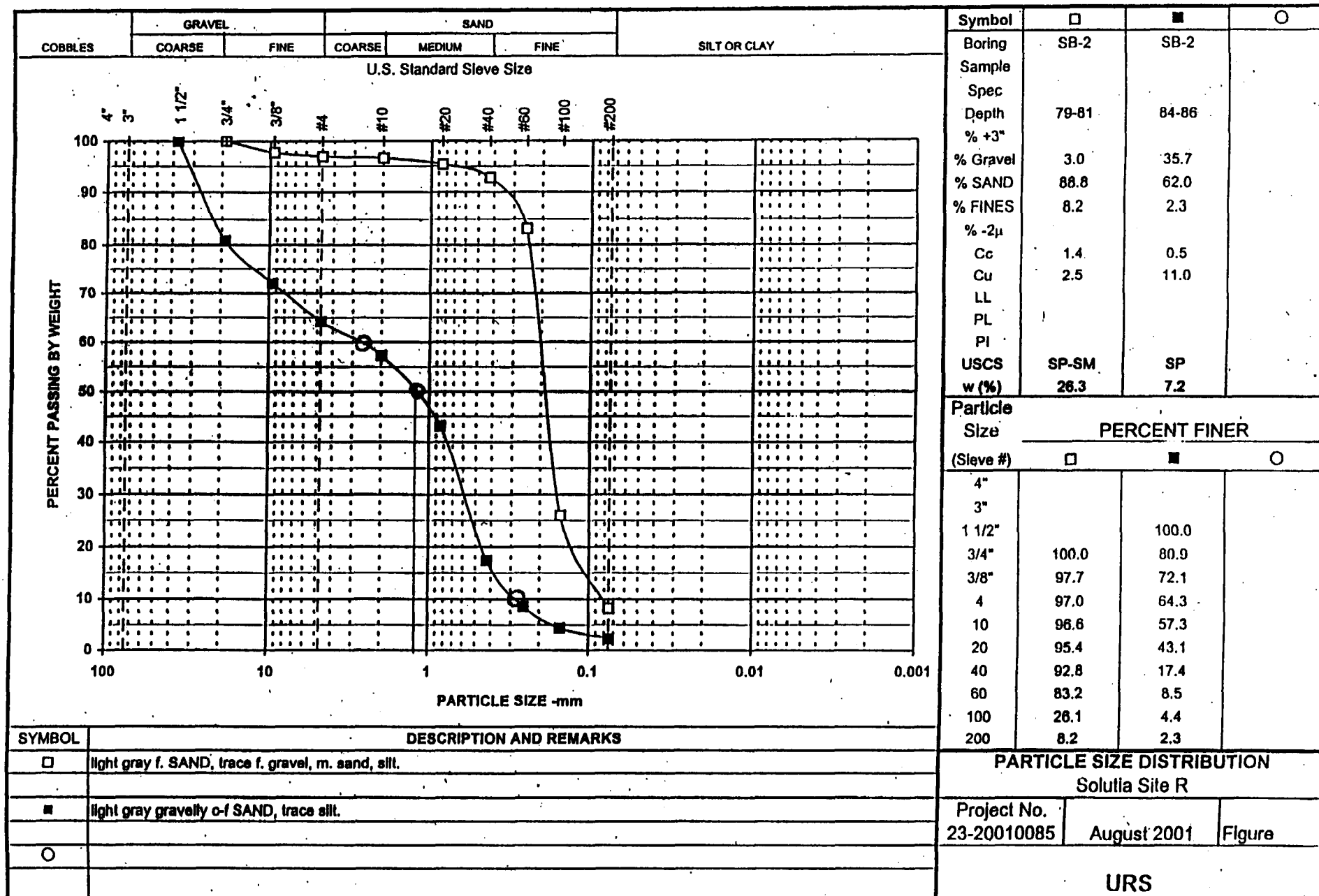
BASED ON SCREEN VELOCITIES, 40 SLOT IS OK

BASED ON SIEVE ANALYSIS, 50 SLOT OR HIGHER IS OK
HOWEVER, INSPECTION OF OTHER INTERVALS AND
BORING SIEVE ANALYSES, FINEER STRATA DO
OCCUR.

THEREFORE USE 40 SLOT SCREEN (0.040 INCH)
FOR WELLS.

11/6/02 NOTE:

SOLUTION REQUESTS 25 FEET OF ADDITIONAL SCREEN
BEGINNING AT 40 FEET BELOW GROUND SURFACE,
IN ORDER TO SCREEN MORE OF THE AQUIFER.
ADDITIONAL SCREEN LENGTH WILL REQUIRE THAT
THE PUMP BE PLACED BELOW TOP OF SCREEN,
BUT NOT SIGNIFICANTLY CHANGE OTHER DESIGN
PARAMETERS. JRS



WELL SCREEN DATA SHEET — TYPE 304 S.S.

LARGE DIAMETER SHALLOW DEPTH STANDARD CONSTRUCTION

Nominal Size	100 Ft							250 Ft						
	OD	Clear ID	Wire Wd	Wire Ht.	Co	Red Area	WT/Ft	OD	Clear ID	Wire Wd	Wire Ht.	Co	Red Area	WT/Ft
6P	6.57	6.02	0.089	0.075	31	0.338	3.70	6.66	6.02	0.116	0.144	200	0.338	4.78
8T	7.53	6.76	0.116	0.144	139	0.432	5.53	7.53	6.76	0.116	0.144	139	0.432	5.53
8P	8.66	7.87	0.116	0.144	91	0.475	6.29	8.66	7.87	0.116	0.144	91	0.475	6.29
10T	9.57	8.66	0.116	0.144	68	0.562	7.07	9.57	8.66	0.116	0.144	68	0.562	7.07
10P	10.69	9.87	0.116	0.144	48	0.605	7.83	10.75	9.87	0.148	0.200	181	0.605	10.61
12T	11.21	10.27	0.116	0.144	42	0.691	8.40	11.27	10.37	0.148	0.200	157	0.691	11.31
12P	12.73	11.84	0.148	0.200	102	0.691	12.49	12.73	11.84	0.148	0.200	102	0.691	12.49
14T	12.43	11.57	0.148	0.200	116	0.562	11.82	12.43	11.57	0.148	0.200	116	0.562	11.82
14P/16T	13.99	13.03	0.148	0.200	82	0.670	13.41	13.99	13.03	0.148	0.200	82	0.670	13.41
16P/18T	16.00	15.05	0.148	0.200	55	0.756	15.30	16.04	15.05	0.150	0.220	71	1.512	23.34
18P/20T	17.80	16.74	0.148	0.200	40	0.778	16.81	17.84	16.74	0.150	0.220	51	1.555	27.76
20P	19.84	18.77	0.148	0.200	29	0.907	18.87	19.88	18.77	0.150	0.220	37	1.814	31.21
24T	21.86	20.66	0.150	0.220	28	1.037	31.10	21.92	20.66	0.158	0.240	40	2.074	42.16
24P/26T	24.03	22.78	0.158	0.240	30	1.964	45.35	24.26	22.78	0.142	0.295	50	1.964	47.75
26P	25.75	24.39	0.158	0.240	25	2.111	48.62	25.90	24.39	0.142	0.295	41	2.111	51.03
30T	27.10	25.73	0.158	0.240	21	2.111	50.79	27.25	25.73	0.142	0.295	35	2.111	53.31
30P/34T	29.70	28.27	0.158	0.240	16	2.455	56.15	29.85	28.27	0.142	0.295	27	2.455	58.88
36P	35.70	34.26	0.142	0.295	16	2.480	70.12	35.85	34.26	0.142	0.295	27	5.696	70.37

To Calculate:

Open area (OA) percent OA = slot/(slot + wire width)

Inlet area (IA) in sq. in./ft. of screen: IA = 37.7 x OD x OA

Transmitting Capacity (TC) in gpm/ft. of screen: TC = IA x 0.31

Tensile Strength (TS) in lbs: TS = Red Area x 30,000 x SF

Hang Weight (HW) in lbs: HW = TS/2

Collapse Strength (ClpS) in psi: ClpS = Co x (wire width/wire width + design slot) x SF

SF = Safety Factor

Co = Collapse strength at zero slot

Slot openings greater than 0.050" may necessitate deviation from standard construction

*WT/FT based on 30 slot construction - no fittings included

**Max. depth = 50 ft.

USF UNITED STATES FILTER CORPORATION

Johnson Screens
P.O. Box 64118
St. Paul, MN 55164
800.VEL WIRE (833-8473) phone
651-656-3900 phone
1-800-328-9891 fax
<http://www.johnsonscreens.usfilter.com>

Waco Screens
14309 Sommerayer Road
Houston, TX 77041
1-800-231-0419 phone
713-939-8567 fax

3204 Lg Diam/SS
Shallow/Std-1199

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GRUNDFOS®

Company name: Grundfos Pumps Corporation USA

Created by: Shawn Chong

Phone: 913.227.3400

Fax: 913.227.3548

Date: 06/02/2003

Position	Count	Description	Single Price
	1	<div></div> <p>625S400-2-A</p> <p>Product No.: 17BG19A2 Multi-stage submersible pump for raw water supply, groundwater lowering and pressure boosting. The pump is suitable for pumping clean, thin, non-aggressive liquids without solid particles or fibres.</p> <p>The pump is made entirely of Stainless steel DIN W.-Nr. 1.4301 DIN W.-Nr. and suitable for horizontal as well as vertical installation. The pump is fitted with a built-in non-return valve.</p> <p>The motor is a 3 -phase motor of the canned type with sand shield, liquid-lubricated bearings and pressure equalizing diaphragm.</p> <p>Liquid: Max liquid t at 0.08 m/sec: 86 °F</p> <p>Technical: Rated flow: 625 US GPM Rated head: 165 ft</p> <p>Materials: Material, pump: Stainless steel 1.4301 DIN W.-Nr. 304 AISI Material, impeller: Stainless steel 1.4301 DIN W.-Nr. 304 AISI Material, motor: Stainless steel 1.4301 DIN W.-Nr. 304 AISI</p> <p>Installation: Size, pump outlet: 6" NPT Motor diameter: 6" inch Minimum borehole diameter: 10" in</p> <p>Electrical data: Motor type: Super - 6" Rated power (P2): 40 HP Mains frequency: 60 Hz Rated voltage: 3 x 460 V Starting method: DOL Rated current: 53.5 A Service factor: 1.15</p>	Price on request



Company name: Grundfos Pumps Corporation USA
Created by: Shawn Chong
Phone: 913.227.3400
Fax: 913.227.3548
Date: 06/02/2003

Position	Count	Description	Single Price
		Rated current: -62 A Starting current: 397 A Cos phi - power factor: 0.86 Rated speed: 3450 rpm Full load motor efficiency: 83.2 %	



Company name: Grundfos Pumps Corporation USA

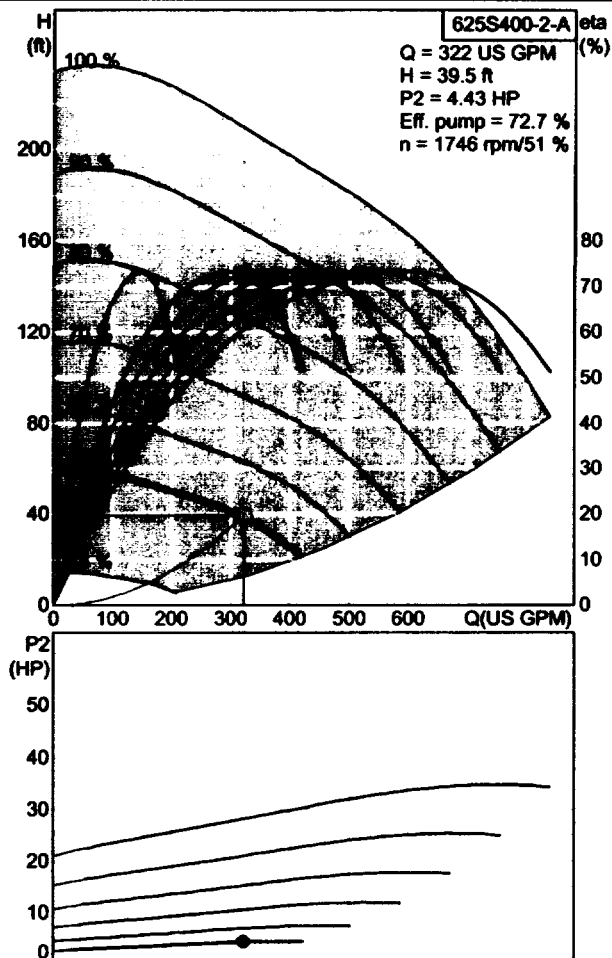
Created by: Shawn Chong

Phone: 913.227.3400

Fax: 913.227.3548

Date: 06/02/2003

Designation	Value
Product Number	17BG19A2
Product name	625S400-2-A
EAN number	5700393567917
Pump Number	17BG00A2
Motor Number	823228F
Stages	2
Impeller reduc.	A
Start. method	DOL
Motor diameter	6" inch
P2	40 HP
Phase	3
U	460 V
Rated current	53.5 A
Service factor	1,15
I start	397 A
n	3450 rpm
Eff. 1/1	83,2 %
f	60 Hz
Rated flow	625 US GPM
Rated head	165 ft
Model	D
Motor type	Super - 6"
Impeller	Stainless steel 1.4301 DIN W.-Nr. 304 AISI
Sales region	Namreg
Cos phi	0,86
Motor protection	None
Thermal protec	External
Pump outlet	6" NPT
Max flow	859 US GPM
I max	62 A
Pump	Stainless steel
Motor	Stainless steel 1.4301 DIN W.-Nr. 304 AISI
Pump	1.4301 DIN W.-Nr. 304 AISI
Axial load max	6010 lb
Applic. motor	Franklin
Valve	Y
Borehole	10" in
Min flow	85.9 US GPM
KVA code	J
Standard	150 A
Delay	70 A
Starter	3
Heather	K77





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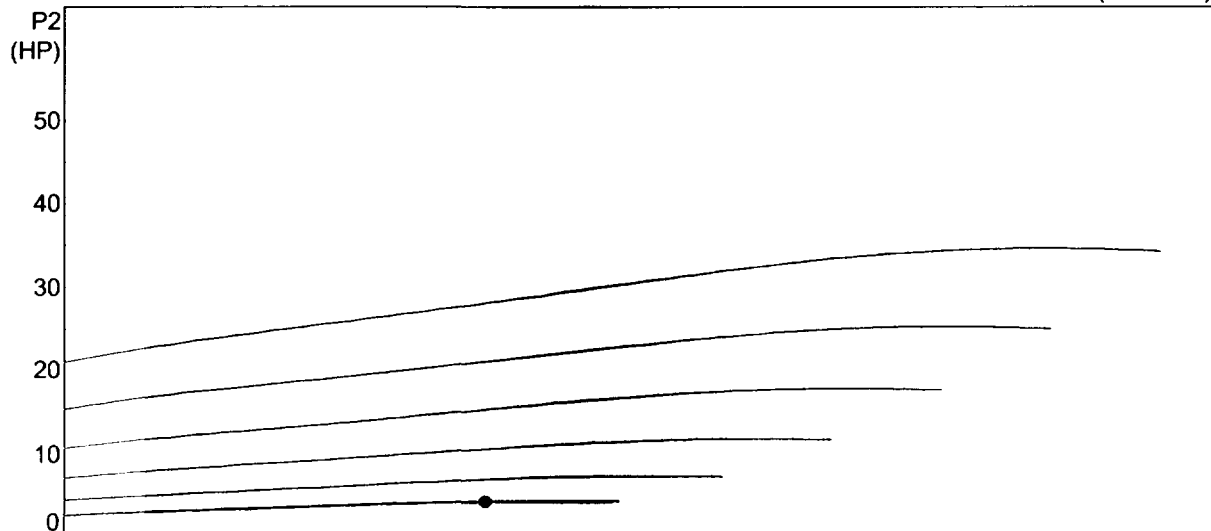
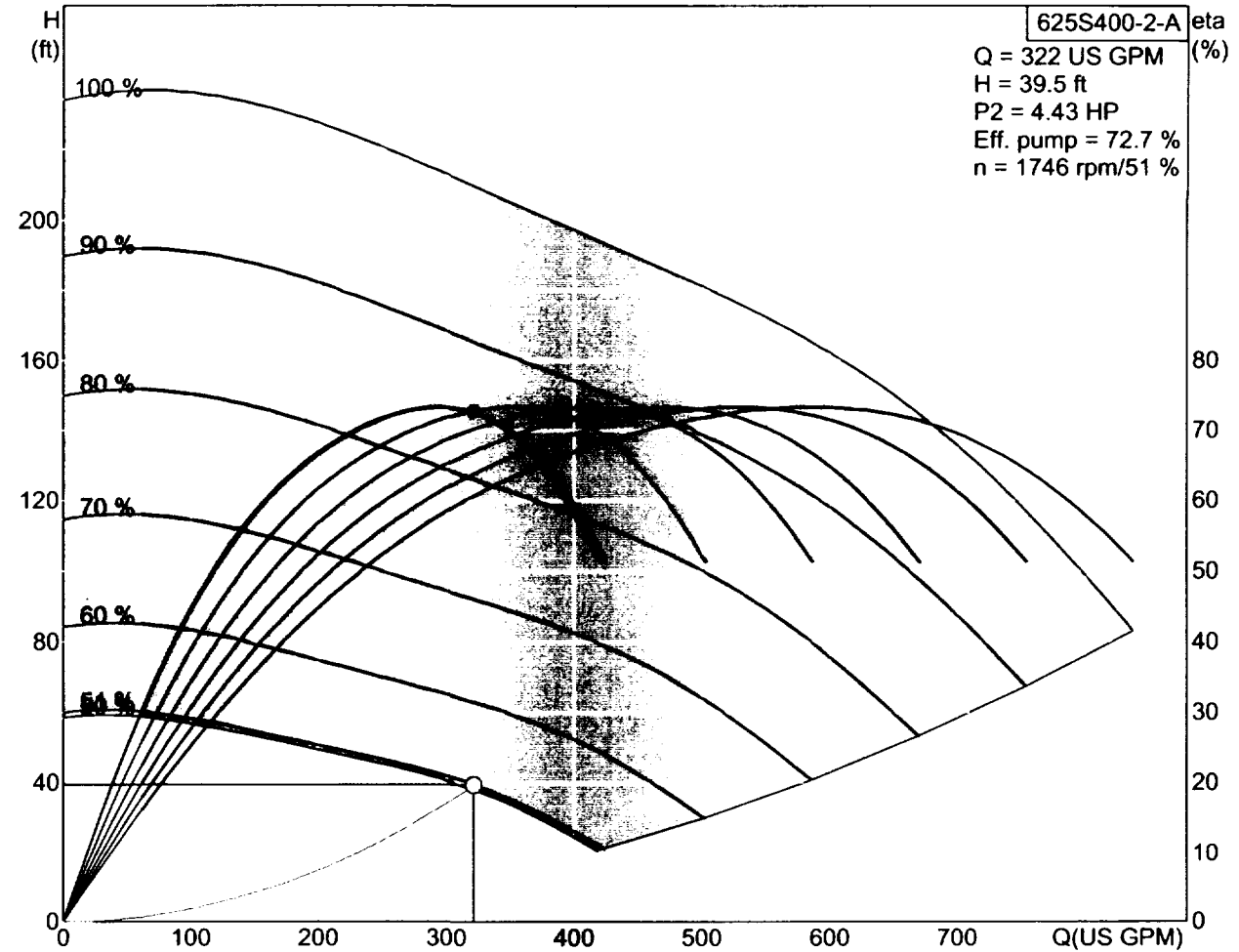
Created by: Shawn Chong

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Fax: 913.227.3548

Date: 06/02/2003

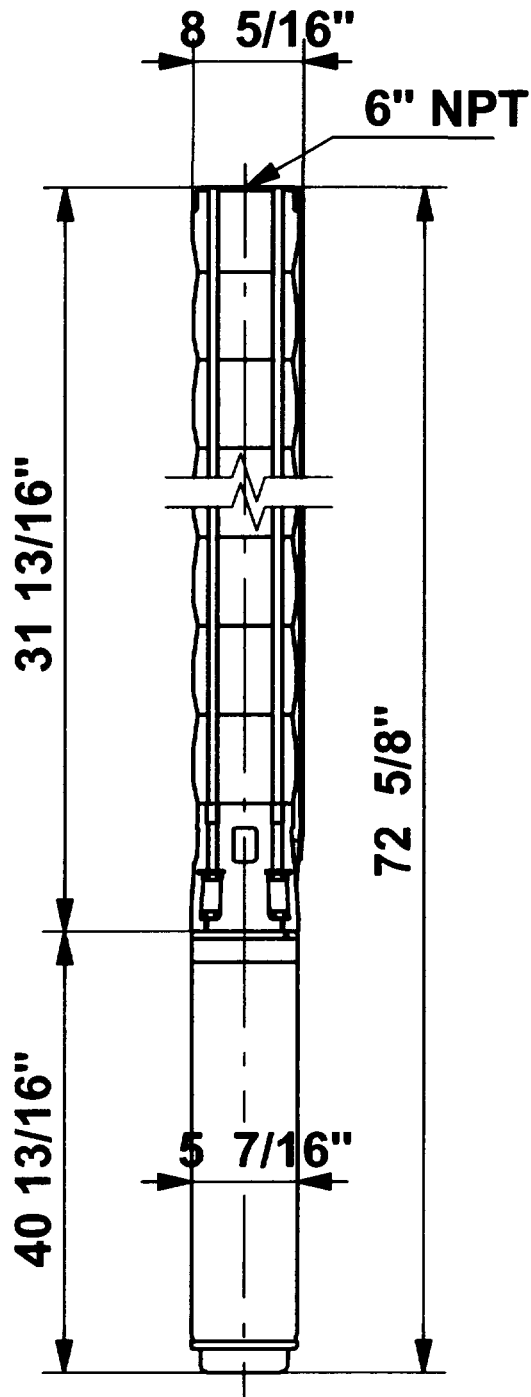
17BG19A2 625S400-2-A





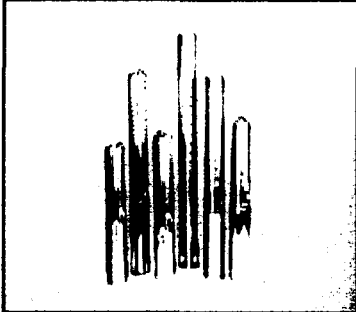
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17BG19A2 625S400-2-A



Note! All units are in [mm] unless others are stated.

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Position	Count	Description	Single Price
	1	<div>475S300-3</div> <div></div> <p>Product No.: 19243003 Multi-stage submersible pump for raw water supply, groundwater lowering and pressure boosting. The pump is suitable for pumping clean, thin, non-aggressive liquids without solid particles or fibres.</p> <p>The pump is made entirely of Stainless steel DIN W.-Nr. 1.4301 DIN W.-Nr. and suitable for horizontal as well as vertical installation. The pump is fitted with a built-in non-return valve.</p> <p>The motor is a 3 -phase motor of the canned type with sand shield, liquid-lubricated bearings and pressure equalizing diaphragm.</p> <p>Technical: Speed for pump data: 3450 rpm Approvals on nameplate: CSA</p> <p>Materials: Material, pump: Stainless steel 1.4301 DIN W.-Nr. 304 AISI Material, impeller: Stainless steel 1.4301 DIN W.-Nr. 304 AISI Material, motor: Stainless steel 1.4301 DIN W.-Nr. 304 AISI</p> <p>Installation: Maximum ambient pressure: 870 psi Size, pump outlet: 5" NPT Motor diameter: 6 inch Minimum borehole diameter: 8" in</p> <p>Electrical data: Motor type: MS6000 Rated power (P2): 30 HP Mains frequency: 60 Hz Rated voltage: 3 x 208-230 V Starting method: DOL Rated current: 101-97,0 A Service factor: 1.15 Rated current: -93 A Starting current: 474 A</p>	Price on request

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Position	Count	Description	Single Price
		Cos phi - power factor: 0,87-0,82 Rated speed: 3450-3480 rpm Full load motor efficiency: 85.0 % Enclosure class (IEC 34-5): IP58 Insulation class (IEC 85): F Built-in temp. transmitter: Y	



Company name: Grundfos Pumps Corporation USA

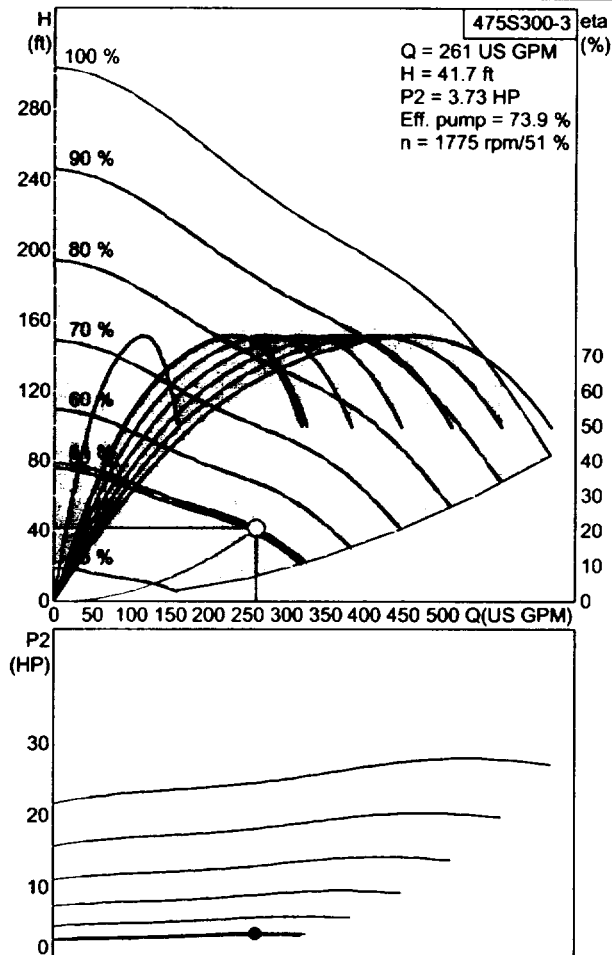
Created by: Shawn Chong

Phone: 913.227.3400

Fax: 913.227.3548

Date: 06/03/2003

Description	Value
Product Number	19243003
Product name	475S300-3
EAN number	5700390085223
Pump Number	19240003
Motor Number	78305518
Stages	3
Temperature Control	Y
Start. method	DOL
Motor diameter	6 inch
IP Class	IP58
Insulation	F
P2	30 HP
Phase	3
U	208-230 V
Rated current	101-97,0 A
Service factor	1,15
I start	474 A
n	3450-3480 rpm
Eff. 1/1	85,0 %
f	60 Hz
Model	B
Motor type	MS6000
n	3450 rpm
Impeller	Stainless steel 1.4301 DIN W.-Nr. 304 AISI
Sales region	Namreg
Cos phi	0,87-0,82
Motor protection	NONE
Thermal protec	EXT.
Pump outlet	5" NPT
Max flow	653 US GPM
Approvals	CSA
I max	93 A
Pump	Stainless steel
Motor	Stainless steel 1.4301 DIN W.-Nr. 304 AISI
Pump	1.4301 DIN W.-Nr. 304 AISI
Axial load max	4410 lb
Ambient pressure maximum	870 psi
Applic. motor	NEMA
Valve	Y
Borehole	8" in
Min flow	65.2 US GPM
KVA code	G
Starter	4 1/2
Heather	K87





Company name: Grundfos Pumps Corporation USA

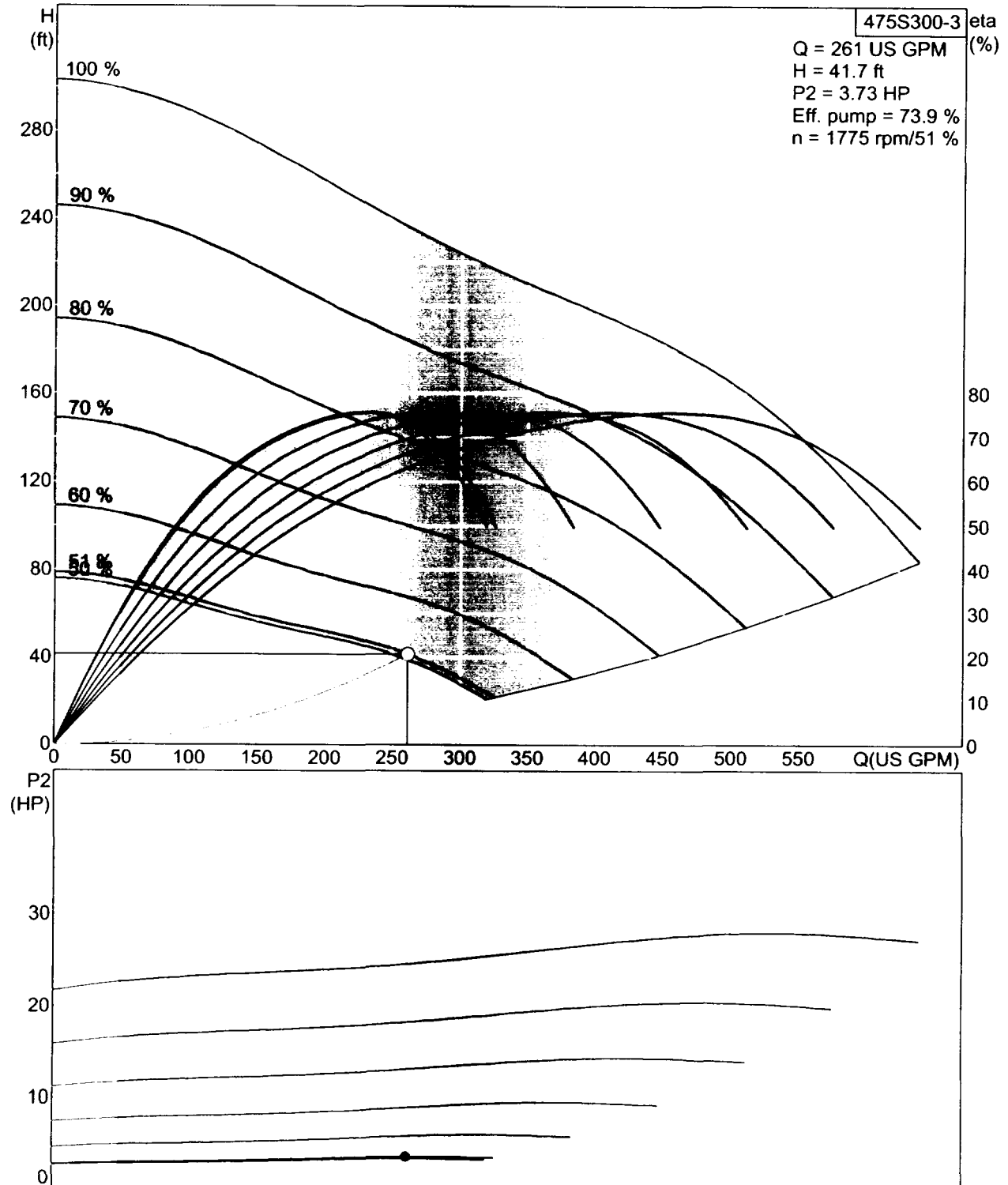
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Date: 06/03/2003

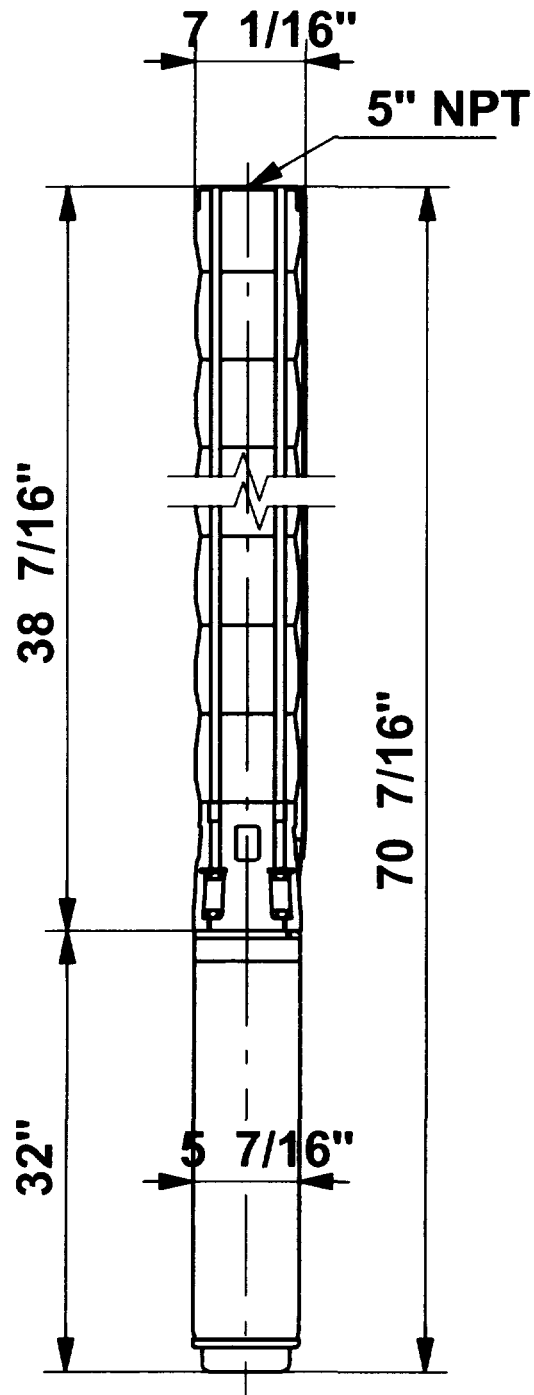
19243003 475S300-3





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Date: 06/03/2003

19243003 475S300-3



Note! All units are in [mm] unless others are stated.

SECTION FOUR

Barrier Wall

The purpose of the barrier wall is to reduce the volume of groundwater flow into the GMCS from the Mississippi River during operation of the groundwater extraction pumps. The pumps are intended to be the principal groundwater control measure for this project. The barrier wall is intended to reduce operation and maintenance (O&M) costs by reducing the volume of water treated. Higher pumping rates will increase O&M costs but will not reduce the ability to abate the impact of groundwater discharge to the Mississippi River from Site R and other nearby sources.

Portions of the design of the barrier wall can not be completed until a contractor has been selected. Once selected, the contractor will provide a design sealed by an engineer registered in the State of Illinois. If an alternate construction technique other than a soil-bentonite wall constructed using the slurry wall technique is proposed, then the contractor will construct a test section, and the contractor's means and methods established during this testing phase will influence design elements such as mix design, element spacing, element lengths, and extraction rates. Therefore, the design for the barrier wall can be finalized once the contractor's design and procedures are known.

4.1 SUBSURFACE CONDITIONS

4.1.1 Geology

This site is located in the American Bottoms physiographic province. The subsurface materials consist of unconsolidated, recent alluvium known as the Cahokia Alluvium, overlying glacio-alluvial outwash known as the Henry Formation. The Cahokia Alluvium is approximately 40-ft thick and consists of unconsolidated, poorly-sorted, fine-grained material with some local sand lenses. These alluvial deposits unconformably overlie the Henry Formation, which is composed of medium to coarse sand and gravel that increases in grain size with depth. This unit is approximately 100-ft thick at the site and generally becomes thinner with increasing distance from the Mississippi River.

The alluvial soils are underlain by Mississippian and Pennsylvanian age bedrock consisting primarily of limestone and dolomite with some sandstone and shale. The bedrock is older in the central and western sections of the American Bottoms.

SECTION FOUR

Barrier Wall

4.1.2 Hydrogeology

Sauget Area 2 is located in the southwestern section of the American Bottoms floodplain. More specifically, it is situated south of East St. Louis, and extends approximately three-quarters to one mile east of the eastern bank of the Mississippi River. The stratigraphy beneath the site is much like that of the rest of the floodplain. The Cahokia Alluvium is about 30 to 40-ft thick consisting of clay and silt with sand zones. Below this, the unconsolidated deposits of the Henry Formation are present. Locally, the Henry Formation is characterized by medium-to-coarse sand that becomes coarser and more permeable with depth. Bedrock is located approximately 130 to 140 ft below ground surface. Cross-sections showing site-specific geology are provided in the Drawings.

Three hydrogeologic units can be identified: 1) a shallow hydrogeologic unit (SHU); 2) a middle hydrogeologic unit (MHU); and 3) a deep hydrogeologic unit (DHU). The SHU is 30 to 40-ft thick and includes the Cahokia Alluvium (recent deposits) and the uppermost portion of the Henry Formation. This unit is primarily an unconsolidated, fine-grained, stratum with low to moderate permeability. The MHU is 40-ft thick and formed by the upper to middle, medium to coarse sand of the Henry Formation. It contains a higher permeability sand than found in the overlying SHU, and these sands become coarser with depth. At the bottom of the aquifer is the DHU, which includes the high permeability, coarse-grained deposits of the lower Henry Formation. This zone is estimated to be about 30 to 40-ft thick.

Recharge to the aquifer occurs through four sources: 1) precipitation; 2) infiltration from the Mississippi River; 3) inflow from the buried valley channel of the Mississippi River; and 4) subsurface flow from the bluffs that border the floodplain on the east.

During normal and low river stage conditions, groundwater at Sauget Area 2 flows from east to west and discharges to the Mississippi River, the natural discharge point for groundwater in the American Bottoms aquifer. When flood stage occurs in the Mississippi River, flow reverses.

4.1.2.1 Results of Recent Field Sampling

From October to December 2002, ten additional borings were drilled along the planned barrier wall alignment. The primary objective of the exploration program was to obtain data from a depth of approximately 70 ft to bedrock, specifically focusing on the attributes of a clay interval

SECTION FOUR

Barrier Wall

that has previously been identified in the area (at depths of approximately 115 to 125 ft below ground surface). Boring logs and other geotechnical data are included in Attachment 4-1 of this volume.

In addition to the drilling program mentioned above, all three permanent wells and eight piezometers to be used for groundwater extraction have been completed.

4.1.3 Geometry, Plan and Elevation

A 3,300-ft long, U-shaped, fully penetrating, barrier wall will be constructed between the downgradient boundary of Sauget Area 2 Site R and the Mississippi River. Plans and details are shown in the Drawings. The barrier wall is designed to reduce recharge from the Mississippi River in the MHU and DHU. It will extend vertically from about 3 ft below grade to the top of bedrock, nominally 130 to 140 ft below grade. The barrier wall will be designed to produce a continuous barrier with minimal gaps. Minor discontinuities may occur because of localized geologic variations, utilities, or other obstructions. These discontinuities, if they exist, are expected to be minor and should not materially affect the performance of the system.

4.1.4 Permeability and Strength

The average design permeability of the in-place wall will be specified to be less than 1×10^{-7} cm/sec based on laboratory testing. This design parameter was chosen as a performance criteria, but is not critical to the design. If the permeability of the wall is greater than indicated above, the system should not be compromised. Because the extraction wells are the primary control mechanisms for this system, additional recharge from the river through the wall would simply result in additional quantities of groundwater to be extracted, but will not influence the objective of the overall control system which is to minimize groundwater discharge to the Mississippi River from the area east of the extraction wells.

4.1.5 Materials

Materials for the barrier wall may include bentonite, water, and the in-situ soils along the wall alignment. Non-toxic and biodegradable admixtures such as fluidifiers and retarders may also be used. The actual backfill mix will be determined by laboratory compatability tests performed by the Owner's Engineer and the Contractor.

SECTION FOUR

Barrier Wall

4.2 BASIS OF BARRIER DESIGN

Design restrictions of the wall alignment are noted in Section 2. Elements of the design of the barrier wall can not be completed until a contractor has been selected. As noted previously, the barrier wall will be constructed using the slurry method or an approved alternate. The ability to construct a continuous barrier with a minimum of discontinuities depends on a number of factors, including:

- The soil type(s)
- The type of excavation equipment
- The type and configuration of mixing equipment
- The backfill mix
- The backfilling procedures

With the exception of the soil type(s), all of these parameters are dependent on the type of equipment selected to construct the wall and, hence, on the contractor. Upon selection, the contractor will provide a final wall design sealed by an engineer registered in the State of Illinois.

Because of the variability in techniques and equipment, the wall and mix parameters cannot be specified until a contractor is selected. Once that selection is made, the contractor will be required to develop and implement a pre-construction test program designed to determine the critical parameters to be used during construction at this site, including mix design and properties.

4.3 CONSTRUCTION METHODS AND SEQUENCE

The barrier wall will be constructed using slurry wall techniques or an approved alternate by a specialty contractor on a design-build basis. Slurry wall construction methods are described herein.

SECTION FOUR

Barrier Wall

4.3.1 Construction Methods

The slurry method of excavation consists of excavating a trench in the existing soils while at the same time keeping the trench filled with bentonite-water slurry. The basic purpose of the slurry is to maintain the stability of the walls of the trench. The slurry is displaced by backfilling material when the wall is constructed. The backfill material is less permeable than the native material, so a groundwater barrier wall then exists.

4.3.2 Construction Sequence

The actual construction sequence will be determined by the selected design-build contractor. Key elements of the construction sequence will include the following:

- Preparation of trial mixes and selection of an optimum mix that is compatible with site groundwater. An initial study of compatibility of grouts with the site groundwater has been performed and is included as Attachment 4-2.
- Mobilization.
- If an alternate installation technique is proposed, construction of a pre-production test cell to verify the adequacy of the design and construction techniques to create a barrier wall with an average permeability of 1×10^{-6} cm/sec or less is required based on in-situ testing. Once the pre-production testing is complete, the site-specific details of the design, including mix composition will be finalized.
- It is anticipated that EPA will be on site during the installation and testing performed for the pre-production test cells if performed. Upon completion of the pre-production tests, it is assumed that the EPA representative on site will approve the pre-production test procedures which yielded a satisfactory product for the barrier wall construction. It is anticipated that this approval will be made in the field and that an additional submittal will not be required.
- Barrier wall installation from the bottom up along the wall alignment.
- If an alternate installation technique is proposed, the Contractor will install two test cells along the wall during production to verify continuity and permeability of the barrier wall.
- Demobilization and site clean up.

SECTIONFOUR

Barrier Wall

4.4 SPOILS HANDLING AND STORAGE

Barrier wall construction will generate spoils that will be collected and transferred to the temporary spoil stockpile. The stockpile is intended to be a temporary facility, and the final disposition of the stockpile will be addressed as part of a future Record Of Decision for Sauget Area 2. The actual method of spoil handling will be determined by the barrier wall contractor; however, spoil will likely be handled by different methods for different portions of the barrier wall. It has been assumed that spoils will be contained in temporary pits for sections of the barrier wall that are parallel to the river where space permits. Spoils will be dried so as to not contain free water before transport to the temporary stockpile. Each open spoil pit will then be backfilled with soil excavated from the adjacent pit or imported clean fill as barrier wall construction proceeds.

It is anticipated that spoil disposal along the north and south legs of the "U" will be handled in a different manner because these sections of the wall will be built on non-Solutia property or through the pavement of Riverview Avenue. In these areas, spoil pits are not practical and the contractor will likely collect the spoil in a container as it is generated. The fluid spoils will be hauled to temporary drying pits, after which the spoils will be removed and trucked to the temporary stockpile where it will be placed and compacted. Drying pits will be restricted to areas outside of the existing Site R landfill, but within the Site R property boundaries.

4.4.1 Volume and Type of Spoils

The volume and type of spoils will depend on the contractor's selected means and methods. There are a variety of types of spoils that could be generated during the construction of the barrier wall. Material from the following sources are expected to comprise the spoils: 1) excavated soil; 2) bentonite slurry; and 3) excess or spilled backfill mix. Therefore, the spoils could be any combination of clay, sand, gravel, and slurry/grout.

For the purpose of this design, it has been estimated that a maximum of 20,000 cubic yards of material will be placed into the temporary stockpile. Actual quantity of spoils is estimated to be less than 10,000 cubic yards based on discussions with a slurry wall contractor. Only solid spoils will be placed in the temporary stockpile.

SECTION FOUR

Barrier Wall

4.4.2 Temporary Spoil Stockpile

A temporary spoil stockpile will be constructed on top of the existing landfill to manage the spoils from the wall construction and other excavations. Once placed into the stockpile area, the spoils will be graded and compacted using a front-end loader or bulldozer.

The stockpile is designed to contain soil or dry, hardened material from the slurry pits. If the slurry is not dry, temporary drying pits may be required prior to placement in the stockpile.

The perimeter of the stockpile will be constructed of clean soil material imported from off site. A daily cover of polyethylene sheeting will be placed over the spoils. A clean soil layer, if needed, will serve to provide a leveling layer between the spoils and an interim HDPE cover as shown in the drawings. Riprap will be placed on the exterior side slopes of the stockpile to protect it from scour and erosion. A vegetative layer will be placed on top of the HDPE cover. The top of the vegetative layer will be at a minimum elevation of 431.8 ft, which is nearly 5 ft above the 100-year flood level, 3 ft above the 500-year flood level, and half a foot above the top of the levee. Therefore, it is not necessary to place riprap on the top of the temporary spoil stockpile.

If the volume of generated spoils is greater than 30,000 cubic yards, the stockpile could be extended in a northerly direction as shown in the Drawings.

4.4.2.1 Stormwater Control

During construction, the contractor will be required to implement a Stormwater Pollution Prevention Plan (SWPPP). The SWPPP will include the design, construction, operations, and maintenance of a run-off management system to collect, control, and treat impacted water resulting from a 24-hour, 25-year storm. The contractor must also design, construct, operate, and maintain a run-on control system capable of preventing flow onto the active portion of the temporary stockpile during the peak discharge from the 25-year storm.

4.4.2.2 Daily Cover/Cap

The spoils material will be covered daily by a polyethylene sheet to minimize wind dispersal, and to minimize the amount of rainfall runoff that contacts the spoils.

SECTION FOUR

Barrier Wall

4.4.2.3 Interim Cover

The filled temporary spoils stockpile will be covered with a clean soil leveling layer, if needed, which will then be covered with a HDPE geomembrane cover. An additional clean soil layer will be placed on top of the HDPE material and will be seeded to form a vegetative layer. Details of the cover are shown on the construction drawings.

4.5 EXPECTED LONG-TERM MONITORING

Long-term monitoring is discussed in detail in Volume 3.

4.6 CALCULATIONS

Hydraulic calculations regarding the anticipated flow rates into the wells, with and without the barrier wall, are provided in the Focused Feasibility Study.

SECTION FIVE

Effluent Pipeline

5.1 DESIGN ASSUMPTIONS AND PARAMETERS

5.1.1 Flows

The effluent pipeline has been conservatively designed for a maximum flow of 667 gpm per well for the three Site R extraction wells, or a total flow of 2,000 gpm, as opposed to the 1,000 gpm flow expected based on the previous hydrogeologic modeling.

5.1.2 Flood Level

The maximum Mississippi River flood stage at the site has been (conservatively) assumed for the purpose of computing external pressure as El 431.5 ft, NGVD, which is the approximate top of the concrete floodwall where the pipeline crosses under the levee. This level corresponds to a flood about 2.7 ft above the 500-year flood level at Mile 178 (above Ohio River) on a Corps of Engineers drawing dated 1979 entitled "Standard River Profiles, Mississippi River, St Louis District." This is the approximate location of the site on the river profile.

5.1.3 Size of Pump Drop Pipe and Head Loss Characteristics

The size of the stainless steel pump drop pipe has been assumed as 6.625-in. OD (6.06-in. ID) in Wells EW-1 and EW-3 and 5.56-in. O.D. (5.04-in. ID) in Well EW-2 (Sch 40 pipe). A Hazen and Williams coefficient of 140 has been used to calculate friction head losses through the stainless steel drop pipe.

5.1.4 Lift

The lift has been computed to be 59 ft from El 363 (about 60 ft below the existing ground surface) to a high point in the discharge line at El 422.

5.1.5 Pipeline Size and Head Loss Characteristics

(See Drawings 2-14 through 2-18.) The pipeline will be 12.75-in. OD SDR 21 HDPE pipe on the river side of the levee. A combination air/vacuum valve will be installed in a manhole at the high point of the pipeline on the river side of the levee. Because the pipeline will be slipped into the existing 30-in. diameter concrete pipe under the levee and the impracticality of ever changing the pipeline diameter there in the future, the pipeline will be increased under the levee to 20-in. OD SDR 13.5 HDPE and will be that diameter to the eastern side of the railroad tracks, where it will be reduced again to 12.75 in. OD SDR 21 HDPE. From the eastern side of the railroad

SECTION FIVE

Effluent Pipeline

tracks to Manholes B and C east of the P-Chem Plant, the pipeline will be 12.75 in. OD SDR 21 HDPE. The pipeline material changes to 12-in. ID ductile iron pipe from a point 3 feet below ground surface where the pipeline rises above ground, and all pipe and fittings from that point to the discharge end will be ductile iron. The friction loss in the HDPE pipeline has been computed using a Hazen and Williams coefficient of 155. The friction losses in the ductile iron pipe have been computed using a Hazen and Williams coefficient of 130. A safety factor of 44 ft of head was added to the total head to account for increasing roughness of the pipe with increasing age.

5.1.6 Discharge Point

The discharge point will be into one of the two open-top manholes (Manhole B and Manhole C) east of the P-Chem Plant. The design will include valves to direct the flow into either manhole. The pipe will elbow over the tops of the manhole walls and terminate inside of the manholes 5 ft below the top of the manhole. The above ground piping and fittings will be heat-traced and insulated. An area light with a dusk-to-dawn cell will be installed on the power service pole. A single phase power service will be provided to power the flow meter and heat trace.

5.1.6.1 Flow Measurement

The flow will be measured at the eastern end of the discharge line using an electromagnetic flow meter. The signal from the flow meter will be transmitted by hard wire to the PLC cabinet at the P-Chem Plant.

5.1.6.2 Water Sampling

Samples of the effluent for American Bottoms Regional Wastewater Treatment Facility will be taken continuously using an American Sigma 900MAX sampler.

5.1.6.3 Check Valve and Plug Valves

There will be a check valve and two plug valves downstream of the flow meter. The check valve will be a rubber flap-type swing check valve with a small closing arc to minimize water hammer. The head loss characteristics of a Valmatic Swing-Flex valve have been used to compute the head loss through the valve. Two iron plug valves will be installed in the two lines downstream of the check valve to permit diversion of the flow into the selected manhole.

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Effluent Pipeline

5.1.7 Pipe Route from Wells to Discharge Point

The location of the pipeline is shown on the Drawings. The pipeline will be laid from Well EW-3 north approximately parallel to the proposed barrier wall to the Solutia easement south of the fence on the south side of the Ameren Power Plant property and north of Riverview Avenue, then east to the levee. On the west side of Pitzman Road, an existing abandoned 30-in. diameter reinforced concrete water line will be exposed and the effluent pipe will be slipped into it to the eastern side of Mobile Avenue. It may not be possible to slip the pipeline into the 30-in. RCP for the entire length between Pitzman Road and Mobile Avenue. As a minimum, the pipeline will extend from the riverside of the levee to the landside east of the first set of railroad tracks. Under the levee, the annulus between the pipeline and the ID of the 30-in. RCP will be grouted full length as indicated on the drawings to prevent piping through the annulus during a flood. East of the railroad tracks, the pipeline may be slipped into the existing 30-in. RCP or laid in its own trench alongside of the 30-in. RCP. Just north of Existing Manhole C east of the levee, the pipeline will turn up through the proposed slab on grade, where the discharge will be metered and samples will be obtained for testing by the American Bottoms Regional Wastewater Treatment Facility. The two pipelines will be supported on pipe supports to Manholes B and C, where they will discharge over the walls and into the manholes 5 ft below the tops of the manholes.

5.1.7.1 Sliplining within Existing 30-in. Concrete Waterline

The current plan is to remove the 6-in. diameter steel sulfuric acid line and its 12-in. diameter steel carrier pipe now within the 30-in. line and slip the new 20-in. OD HDPE line through the 30-in. diameter line. The annulus between the OD of the new 20-in. diameter HDPE pipe and the ID of the existing 30-in. diameter concrete pipe will be grouted full length under the levee to prevent water from flowing through the annulus during a flood.

5.1.8 Air Release/Vacuum Relief Valves

A combination air valve will be installed in a manhole at the high point of the pipeline on the western side of the levee and an air release valve will be installed at the discharge point.

SECTION FIVE

Effluent Pipeline

5.2 DESIGN RESTRICTIONS

5.2.1 Capacity of Well Pumps

The pumps will be 30-40 HP pumps with limited head capacity. When final selection of the pumps is made, system curves will be developed and these curves will define the flow for a given pumping water level in the wells and the particular pumps being used.

5.3 CALCULATIONS

5.3.1 Total Dynamic Head (Maximum Flow)

The total dynamic head for a flow of 333 gpm per well is about 125 ft, calculated as shown in Attachment 5-1a. A safety factor of 44 ft of head has been added to the total head account for increasing roughness in the pipeline with age. The friction losses were computed based on the Hazen and Williams formula with the coefficients given above and detailed in Attachment 5-1a. The total head was also computed for a flow of 667 gpm per well. With the 44-ft allowance for increased roughness in the pipe, the total computed head is 178 ft, or 53 ft more than the total head computed for the 333-gpm per well flow. This increase in head will be reduced considerably should larger pumps be required by using larger diameter drop pipe and fittings (5-in. or 6-in. nominal diameter) in the wells and larger pipe and fittings between the well and the effluent pipeline.

5.3.2 Internal Pressure

The maximum normal internal pressure in the pipeline will be the sum of head losses between Well EW-1 and the high point in the pipeline farthest from Well EW-1 plus the difference in the pipe elevation between Well EW-1 (El 416) and the high point in the line (El 423). This total head (for a well flow of 333 gpm) is about $49 + 7 = 56$ ft, or about 24 psi. Transient pressures caused by check valves closing could increase the pressure within the pipeline. No calculations have been made to estimate the magnitude of the water hammer pressures. Based on experience, SDR 21 pipe was selected for the pipeline. SDR 21 pipe has a pressure rating of 80 psi at a temperature of 73.48 F. The groundwater at the site will have a constant temperature of around 55.8 F, which would increase the pressure rating to about 88 psi. The minimum internal pressure will be 0 psi (gage) because of the combination air valve at the high point in the line.

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Effluent Pipeline

5.3.3 External Pressure

External pressures will be exerted on the pipeline by water, earth, and vehicle loads. The maximum water pressures will occur during floods at the low point in the line on the river side of the levee. Assuming the maximum river stage at the top of the flood wall (El 431.5) and the lowest point in the line is at Well EW-3 (El 416), the maximum external water pressure is 15.5 ft of water, or about 7 psi. The maximum earth loading is the submerged weight of soil above the pipeline at its deepest cover, about 6 ft at Riverview Drive. At this point the maximum earth load would be about 3 psi. Based on a design chart published by Driscopipe, an H20 highway loading would add 6.3 psi of external pressure to a pipeline with a minimum cover of 3 ft. There would be no vehicular loads during a flood, so the maximum external pressure would be the dry weight of 6 ft of earth (5.2 psi) plus a vehicular load of 6.3 psi = 11.5 psi. This compares to a lesser load of $7 + 3 = 10$ psi during a flood. The design burial calculations by Driscopipe¹ indicate that if SDR 21 Driscopipe 1000 Series HDPE pipe is bedded in clean sand compacted to at least 85% of standard Proctor density with a minimum cover of 3 ft, the ring deflection is acceptable, the crushing design safety factor is 16.9, and the wall buckling design safety factor is 8.5.

5.4 MATERIALS, VALVES, INSTRUMENTATION, AND FITTINGS

5.4.1 HDPE Pipe and Fittings

SDR 21 pipe ranging from 12.75 in. OD to 24 in. OD will be used for the pipeline.

5.4.2 Ductile Iron Pipe and Fittings

Ductile iron pipe will be pressure class 350 pipe (0.28-in. wall thickness for 12-in. nominal diameter pipe) with mechanical joints where buried and flanged joints where the pipe is above ground. Thrust blocks will be cast to restrain joints at elbows with mechanical joints. The aboveground pipe and fittings will be supported on steel supports anchored to the slab on grade. Outside of the concrete slab, the pipe will be supported on reinforced concrete pipe supports.

5.4.3 Bedding Material

The pipeline will be bedded in clean sand extending from 6 in. below the pipe to 6 in. above the crown, and the sand will be compacted.

SECTION FIVE

Effluent Pipeline

5.4.4 Valves

The two valves at the discharge end of the pipeline will be flanged-end, gear-operated Milliken Millcentric Fig. 601 eccentric plug valves or equivalent. The check valve will be a flanged-end rubber flapper swing check valve equal to Apco Series 100 or Valmatic Swing-Flex, equipped with a hold-open device for backflushing. The combination air valve will be an Apco single body double orifice valve or a Valmatic single housing style combination air valve. (The exact size of this valve has not been selected yet.) An air release valve (Valmatic Model No. 22 simple lever type, 1-in. NPT inlet size) will be installed upstream of the flow meter to release small amounts of entrained air that may be in the effluent at that point.

5.4.5 Flow Meter

The flow meter will be a 12-in. Krohne Aquaflux or equal magnetic flow meter with flanged ends, IP67 rated, integral signal converter, 115AC powered, NEMA 4X rated, and digital display of rate and total. The signal from the flow meter will be transmitted to ABRTF via spread spectrum radio telemetry (Elpro).

5.4.6 Continuous Sampler

The water sampler will be an American Sigma 900 MAX all-weather refrigerated sampler, 115 VAC, with a 6-ft power cord and pump tube insert. It shall be equipped with a set of four 3-gallon polyethylene bottles, a distributor with arm (2/4 bottle, AWRS), and a 10-ft long multi-purpose half cable.

5.4.7 Foundation

As a minimum, the foundation will consist of a 12-in. thick reinforced concrete slab on grade extending 3 in. above the surrounding grade. This slab may be eliminated and individual pipe supports installed with a separate concrete slab on grade to support the sampler.

Attachment 5-1 Calculations

By: G.R. Bird June 26, 2003

Attachment 5-1a. Design Calculations: Total Dynamic Head
Well Pumps at Site R Only (666 gpm/well), 6" Drop Pipe, 12" Header (20" Under Levee and RR Tracks)

Well EW-3 (farthest south)

High point in discharge line (Ft, NGVD)	422.0	Total Head Loss (Ft)	79.0
Pumping Water Level (Ft, NGVD)	363.0	Lift	59.0
Pump Setting (Ft, NGVD)	360.0	Total Dynamic Head (Ft)	138.0
Drop Pipe Dia (In.)	6	Minimum Size Grundfos Pump: 625S400-2-1 (40 HP); 667 gpm at 148 ft	

Head loss (K) factors are from *Engineering Data Book*, 2nd Edition (1990), Hydraulic Institute

Friction loss data for HDPE pipe from Driscopipe Systems Design (1991)

Friction losses computed using Hazen-Williams formula

Run	Dia. (In.)	ID (in.)	Flow (gpm)	h_f (ft/100 ft)	Length (ft)	K	v (ft/sec)	$v^2/2g$ (ft)	Head Loss (ft)	Remarks
Pump discharge loss	6	6.06	667				7.42	0.86	0.0	
Well EW-3 SS Drop Pipe (360 to 418)	6	6.06	667	2.95	58		7.42	0.86	1.7	new Sch 40 steel pipe (Hazen & Williams C = 140)
Pitless adapter 90° elbow	6	6.06	667			0.65	7.42	0.86	0.6	
6" SDR 11 HDPE pipe (horizontal; allow 20 ft)	6	5.35	667	4.47	10		9.52	1.41	0.4	Hazen & Williams C = 155; assume 6" magnetic flow meter in pit; no additional head loss
6" valve	6	6.06	667						0.7	From Dezurik catalog
6" x 2" tee (run)	6	6.06	667							(negligible)
6" SDR 11 HDPE pipe	6	5.35	667	4.47	10		9.52	1.41	0.4	Hazen & Williams C = 155
6" x 12" tee, branch flow	6	6.06	667			0.53	7.42	0.86	0.5	
12.75" OD SDR 21 HDPE to Well EW-2	12	11.536	667	0.11	580		2.05	0.07	0.6	Hazen & Williams C = 155
12.75" OD SDR 21 HDPE Well EW-2 to Well EW-1	12	11.536	1333	0.38	760		4.09	0.26	2.9	Hazen & Williams C = 155
12.75" OD SDR 21 HDPE Well EW-1 to EW discharge line	12	11.536	2000	0.81	330		6.14	0.59	2.7	Hazen & Williams C = 155
12.75" OD SDR 21 HDPE western end to west side of Pitzman Ave	12	11.536	2000	0.81	1310		6.14	0.59	10.7	Hazen & Williams C = 155
12" x 20" enlargement	20	16.86	2000	0.13			2.88	0.13	0.5	Hazen & Williams C = 155
20" OD SDR 13.5 HDPE to landside	20	16.86	2000	0.13	300		2.88	0.13	0.4	Hazen & Williams C = 155
12.75" OD SDR 21 HDPE Landside to P Chem Manhole	12	11.536	2000	0.81	1200		6.14	0.59	9.8	Hazen & Williams C = 155
20 x 12 reducer	12	11.536	2000				6.14	0.59	0.5	
12.75" OD tee	12	11.536	2000			0.5	6.14	0.59	0.3	
12.75" OD 90-degr elbow	12	11.536	2000			0.5	6.14	0.59	0.3	
12.75" OD 90-degr elbow	12	11.536	2000			0.5	6.14	0.59	0.3	
12.75" OD 90-degr elbow	12	11.536	2000			0.5	6.14	0.59	0.3	
12.75" OD pipe	12	11.536	2000	0.81	54		6.14	0.59	0.4	Hazen & Williams C = 130
Valmatic Swingflex check valve	12	11.536	2000						0.5	From manufacturer's curve
Exit loss	12	11.536	2000			1.0	6.14	0.59	0.6	
Subtotal pipeline head loss									35.0	
Safety Factor					4480				44.0	safety factor for decreased C factor with age
Total head loss									79.0	

SECTION SIX

Automated Control and Monitoring System

The Automated Control and Monitoring System (ACMS) is a primary component of the Groundwater Migration Control System (GMCS). The primary function of the ACMS will be to automatically monitor stage level of the Mississippi River and adjust pumping rates of the three extraction wells. A secondary function of the ACMS will be to monitor the water level in four pairs of piezometers, which will be equally spaced along the west side of the U-shaped barrier wall. One piezometer of each pair will be located inside the barrier wall and one will be located outside the wall. These piezometer readings will be used by the ACMS to further adjust pumping rates to minimize groundwater gradients across the barrier wall.

6.1 DESIGN PARAMETERS

The ACMS will be designed using the following parameters:

- Automatically monitor water level and flow rate of three (two 12-in. diameter and one 10-in. diameter) extraction wells. Each well will have a nominal pumping capacity of 667 gpm with a total system capacity of 2,000 gpm. Extraction well pumps will use –30 and 40 HP motors. The 30 HP motor will be used in the 10-in. diameter well. The 40 HP motors will be used in the 12-in. diameter wells.
- Automatically monitor water levels in four pairs of piezometers along the west wall of the proposed barrier wall.
- Automatically read and record Mississippi River stage elevations.
- Automatically adjust pump flow rates based upon calculated combined pump flow rates for specific river stages as shown on Drawing 6-02.
- Maintain “zero” gradient condition across the barrier wall based upon average water levels measured at piezometer pairs along the west wall of barrier wall.
- Provide the ability to remotely monitor and adjust pump flow rates, monitor river stage, automated piezometer levels, and extraction well water levels.
- Provide capability for remote alarm annunciation in the event of system operational problems.
- Maintain instrument readings database for archiving purposes.

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Automated Control and Monitoring System

6.2 DESIGN CONSTRAINTS

The ACMS will be designed to accommodate the following site constraints:

- ACMS components will be selected and located to minimize potential effects of a 100-year flood event, approximate elevation 425 ft at Site R.
- AC power will not be available at the automated piezometer locations.

6.3 THEORY OF OPERATION

The three extraction well pumping rates will primarily be a function of river stage. Drawing 6-02 shows the calculated combined pumping rates for the three wells based on river stage. As shown on Drawing 6-02 the calculated combined pump flow rates range from 0 to about 1,950 gpm for corresponding river elevations of 413 to 374. For reference purposes, the 100-year flood stage at Site R is about elevation 425.

When the Mississippi River stage reaches elevation 413 the pumping system will automatically shutdown. The system will automatically restart pumping once the river level falls below elevation 413.

Occasionally it may be necessary to temporarily increase extraction well pumping rates to maintain a "zero" gradient across the barrier wall. As mentioned above, water levels in the four pairs of piezometers, along the west wall of the proposed barrier wall, will be read automatically. If the average water level inside the barrier wall is greater than the average water level outside the barrier wall for a period of two days, the extraction well pumping rates will be increased until a "zero" gradient condition is reestablished across the wall.

The ACMS will employ variable frequency drives (VFDs) on each of the extraction well pump motors. The VFDs will provide the ability to optimize overall performance of the GMCS resulting in reduced energy and extracted groundwater treatment costs.

6.4 OVERVIEW OF ACMS

The ACMS will consist of the following key components:

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Automated Control and Monitoring System

- Measurement and Control Unit (MCU)
- River stage gauge
- Power distribution panel
- Pump control panels with variable frequency drives
- Magnetic flow meters at each extraction well
- Automated piezometer pairs along west barrier wall
- Host/Remote Access PC located in on-site portable control house.

6.4.1 Measurement and Control Unit (MCU)

The measurement and control unit (MCU) will receive river stage readings from a river stage gage located at the northwest corner of Site R. The MCU will send signals to a variable frequency drive at each of the extraction wells. The variable frequency drives will maintain the appropriate pump motor speed to produce the necessary pump flow rate based upon the current river stage. The system design incorporates magnetic flow meters at each extraction well. The flow meters will provide closed-loop feedback to the VFDs and relay current flow rates for each of the extraction wells to the MCU. A secondary system control protocol employs automated readings of four pairs of piezometers along the west wall of the proposed barrier. If the water level differential inside the barrier wall is greater than “zero” gradient for a period of two days, the extraction wells pumping rate will be increased. The increased pumping rate will be maintained until the “zero” gradient condition is reestablished. The frequency of readings and necessary pumping rate adjustments will be made on an hourly basis. The river stage, individual pump flow and automated piezometer readings will be stored and time stamped each hour.

The MCU will have a conventional phone modem for remote access via the host computer. The host computer will serve as a gateway to the on-site MCU. Host computer software will include vendor-supplied applications to interface with the MCU. Users will be able to view current water level information, flow rates and river stage levels. It will also be possible to make changes to the control application software to adjust reading frequencies, threshold levels and to perform remote system diagnostics. The vendor-supplied software will include a database to store automated readings.

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Automated Control and Monitoring System

If the pumps stop for some reason, the VFD will instantly generate an alarm and the received fault signal at the MCU will result in the MCU logging the event and dialing, via the phone line, to notify appropriate personnel.

A system block diagram is provided in the Drawings. Manufacturer's cut-sheets and technical specifications are given in this volume.

6.4.2 River Stage Transmitter

The river stage gauge (RS-1) is an existing bubbler-type water level indicator owned and operated by the American Bottoms Regional Wastewater Treatment Facility (ABRWTF). We will share the river stage signal for use by the ACMS. This gauge will be connected to the MCU via direct buried cable. The MCU will convert the raw signal to river stage elevation.

6.4.3 Power Distribution Panel

There will be a new power distribution panel located at the existing power pole and service entrance located on the north side of the site. The power distribution panel will be sized to accommodate power connections for the three extraction well pumps and disconnects. There will also be disconnects at each well location.

All of the wiring from the power distribution panel to the three extraction wells will be direct buried cable. All power for the VFDs and the pump motors will be 480vac, 60hz, 3 phase. There will also be a separate breaker and a separate 120vac circuit installed at each well location area.

6.4.4 Pump Control Panels with Variable Frequency Drives

A pump control panel will be located above grade at each of the extraction wells. The individual pump control panel will be housed in an enclosure that will also include the variable frequency drive and flow meter readout unit. The pump control enclosure will be set at an elevation 1 ft above the 100-year flood event (approximately 5 ft above existing grade).

A Reliance Electric SP600 variable frequency AC drive (VFD) will operate each pump motor. The VFD will allow variable speed operation of the pump motor and allow a variable pumping flow rate to be achieved by each pump motor. By using a flow meter at each well, the flow meter's 4-20ma output will provide a feedback signal to the MCU to allow closed loop operation

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Automated Control and Monitoring System

of the pumps. This will allow the VFD to maintain the flow set point provided by the MCU for a given river stage elevation. Each VFD will provide switch closure signals to the MCU to indicate fault conditions. As previously described, the MCU will then generate an alarm annunciation.

A small manual pump control panel will be located at each extraction well. The pump control panel will be mounted in the same enclosure as the VFD and flow meter readout unit. The VFD will incorporate an automatic control bypass mode to allow manual starting and stopping of the pump motor. There will be a manual speed control dial to adjust pump speed.

6.4.5 Magnetic Flow Meters

Magnetic flow meters will be installed at each extraction well location. The magnetic flow meters will measure pump flow rate and work in conjunction with the VFDs to maintain optimum pump speed to achieve required pumping rate. The magnetic flow meters will be 6-in. diameter and will be mounted in the flow meter vault at each extraction well. The flow meters will output a 4-20ma signal to the MCU. Manufacturer literature and specifications are attached.

6.5 ANTICIPATED LONG-TERM MONITORING AND OPERATIONAL REQUIREMENTS

The ACMS is designed for unattended operation. The system will incorporate necessary alarm annunciation in the event of fault conditions during system operation. The system design includes the ability to remotely perform system diagnostics via the host PC.

In the event of a major flood event, pump disconnects will be located near the pole barn. Since it isn't necessary to operate the extraction pumping system during high river stages it will be possible to completely shut power off to the entire pumping system until flood waters recede.

Detailed ACMS operations and maintenance procedures will be prepared as part of the overall O&M plan for the project.

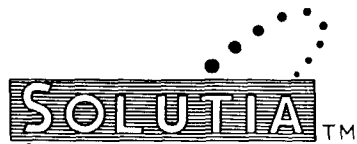
**Groundwater Migration Control System
Prefinal Design Submittal
Sauget Area 2 Superfund Site**

**Volume 1
Revision No.: 3
Date: 07/03/03**

Drawings

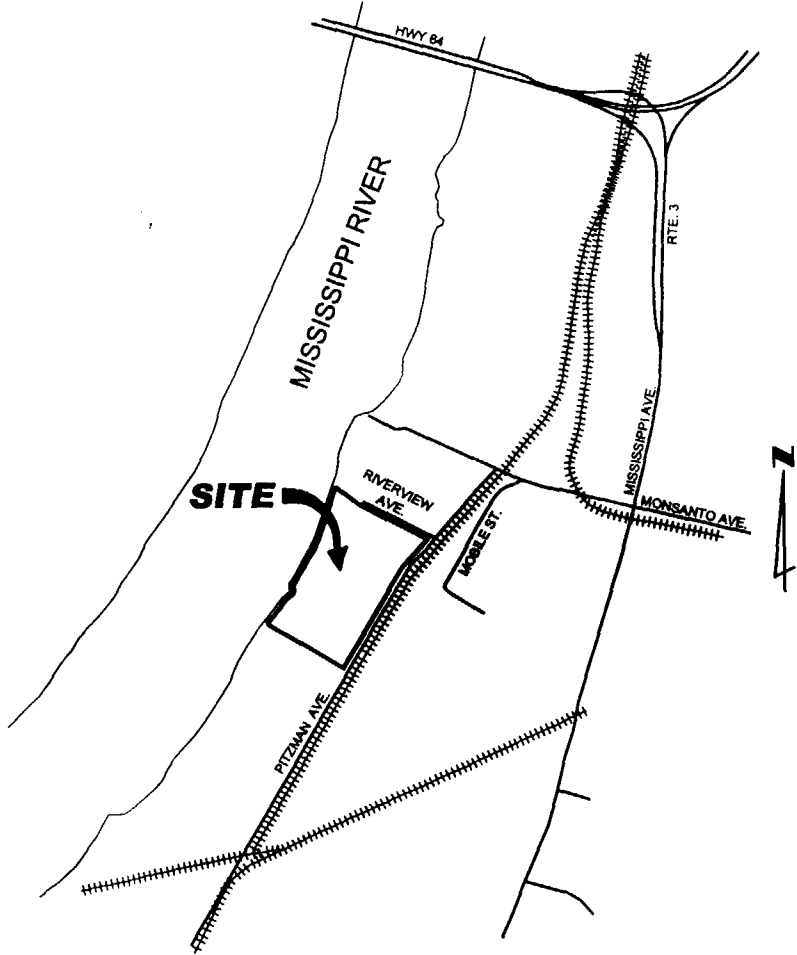
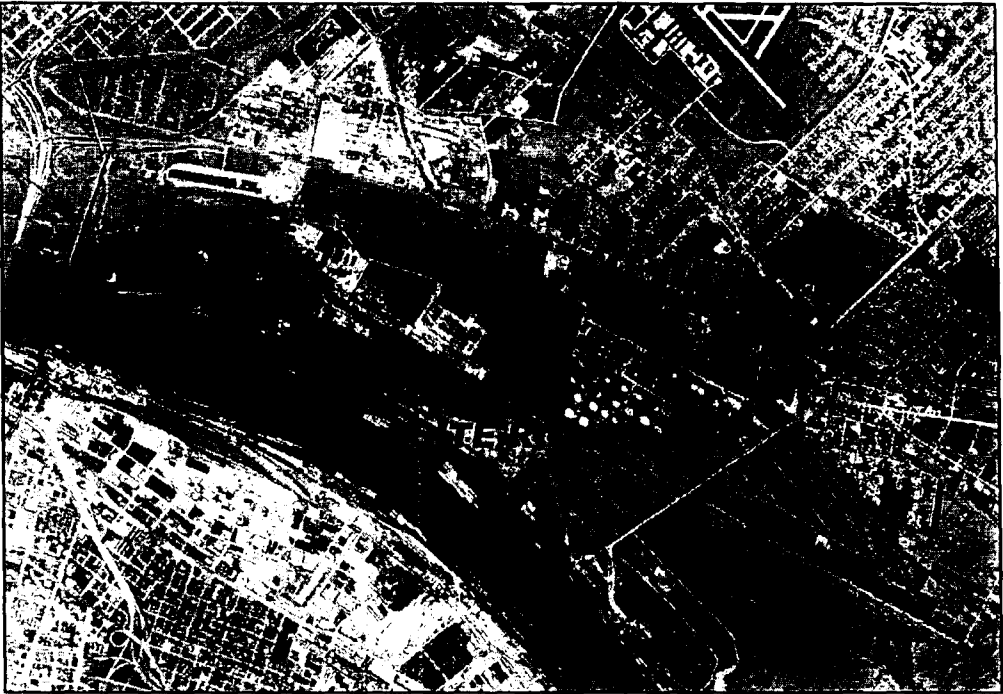
SITE R
SAUGET, ILLINOIS

GROUNDWATER MIGRATION CONTROL SYSTEM
AUTOMATED CONTROL AND MONITORING SYSTEM



INDEX

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**LOCATION
MAP**

NOTE:

EXISTING SURFACE FEATURES HAVE BEEN PLOTTED FROM AN AERIAL SURVEY BY SURDEX. THE LOCATIONS OF UNDERGROUND UTILITIES, STRUCTURES AND FACILITIES HAVE BEEN PLOTTED FROM PLANS AND DRAWINGS OF EXISTING FACILITIES PROVIDED BY SOLUTIA. THEIR LOCATIONS MUST BE CONSIDERED APPROXIMATE ONLY. THERE MAY BE OTHER IMPROVEMENTS AND UTILITIES WITHIN THE PROJECT AREA, WHICH ARE NOT SHOWN. THE CONTRACTOR SHALL VERIFY, PRIOR TO EXCAVATION OR CONSTRUCTION, THE LOCATIONS, ELEVATIONS AND DIMENSIONS OF ALL EXISTING UTILITIES, STRUCTURES, WELLS AND OTHER FEATURES AFFECTING HIS WORK, WHETHER OR NOT SHOWN ON THE PLANS. USE OF A SUBSURFACE LOCATOR IS RECOMMENDED.

SHOULD ANY FEATURE ADVERSELY AFFECT THE PROPOSED CONSTRUCTION, THE CONTRACTOR SHALL OBTAIN SOLUTIA'S APPROVAL FOR A CHANGE OR MODIFICATION TO THESE PLANS PRIOR TO PROCEEDING.

DATE: 7/3/03
SCALE: AS SHOWN
DESIGNED: DJD/WDL
DRAWN: DJD/WDL
CHECKED: JH
SUBMITTED:

PREPARED BY:



1001 Highlands Plaza Dr.
West, Suite 300
St. Louis, MO 63110
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PROJECT NO.	21561238.00000
SHEET NO.	2-01

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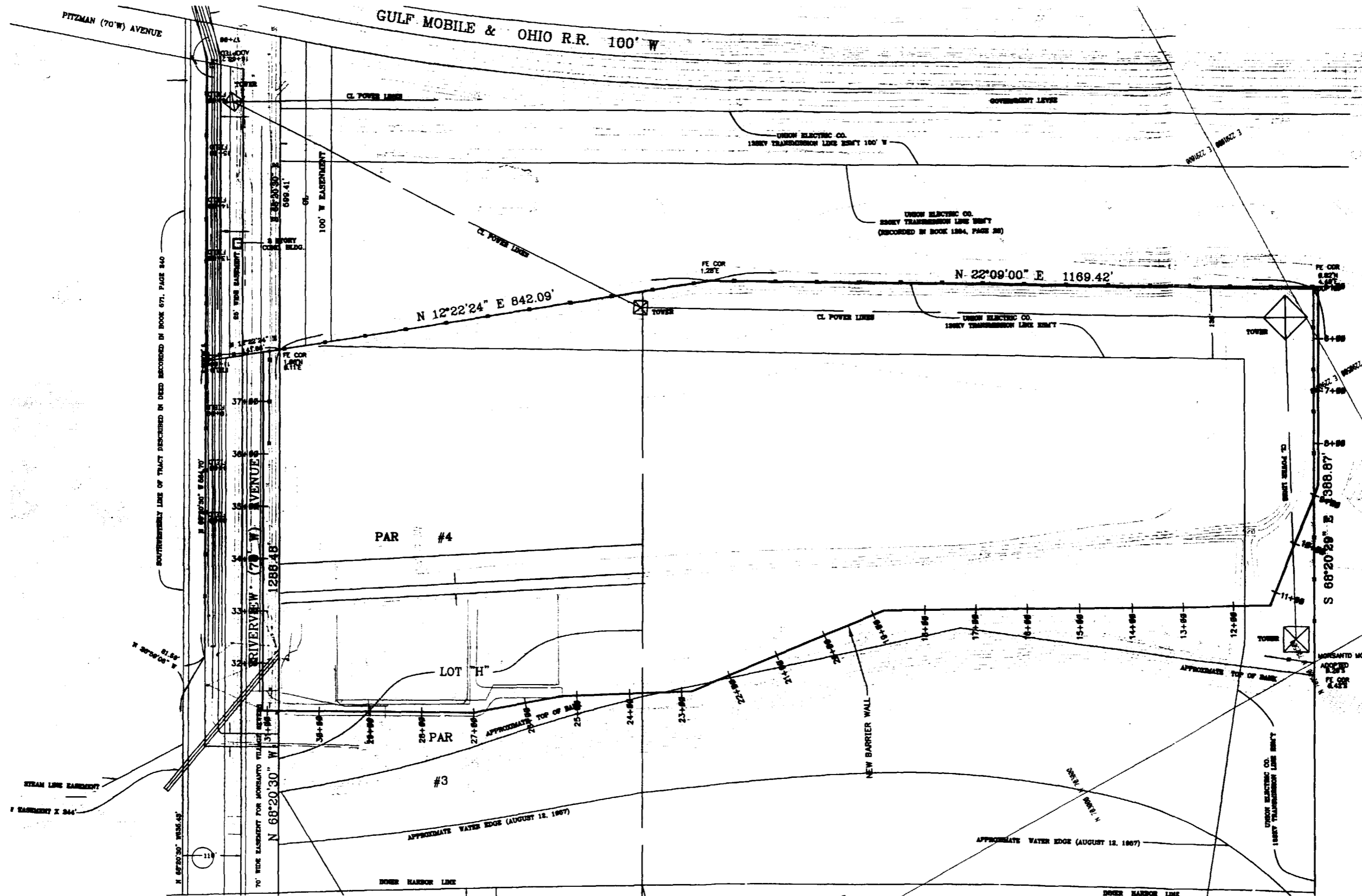
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URS PROJECT NO.
21561192.00001
SHEET NO.
2-02

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NO.	DATE	REVISION DESCRIPTION	APPROVED

METRONA Surveying Co.

2505 METRO BLVD. SUITE J
MARYLAND HEIGHTS, MO. 63043
314-432-5400 FAX: 314-432-5401

SEAL

DATE: 7/3/03
SCALE: AS SHOWN
DESIGNED:
DRAWN: DJD/VDL
CHECKED: MJB
SUBMITTED:



SOLUTIA INC.
575 MARYVILLE CENTRE DRIVE
ST. LOUIS, MO. 63141

GROUNDWATER MIGRATION CONTROL SYSTEM

EFFLUENT PIPELINE

EXISTING PROPERTY AND TOPOGRAPHY PLAN

PROJECT NO.

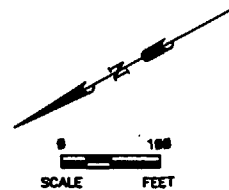
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
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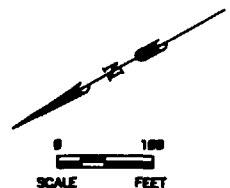
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EXISTING SURFACE FEATURES HAVE BEEN PLOTTED FROM AN AERIAL SURVEY BY SURDEX. THE LOCATIONS OF UNDERGROUND UTILITIES, STRUCTURES AND FACILITIES HAVE BEEN PLOTTED FROM PLANS AND DRAWINGS OF EXISTING FACILITIES PROVIDED BY SOUTIA. THEIR LOCATIONS MUST BE CONSIDERED APPROXIMATE ONLY. THERE MAY BE OTHER IMPROVEMENTS AND UTILITIES WITHIN THE PROJECT AREA, WHICH ARE NOT SHOWN. THE CONTRACTOR SHALL VERIFY, PRIOR TO EXCAVATION OR CONSTRUCTION, THE LOCATIONS, ELEVATIONS AND DIMENSIONS OF ALL EXISTING UTILITIES, STRUCTURES, WELLS AND OTHER FEATURES AFFECTING HIS WORK, WHETHER OR NOT SHOWN ON THE PLANS. USE OF A SUBSURFACE LOCATOR IS RECOMMENDED.


 CPT - Cone Penetrometer Location (2001)
 Sonic - Sonic Boring Location (2002)
 SB - Standard Penetration Test Boring (2001 AND 2002)



PREPARED BY:

URS

1001 Highlands Plaza Dr. West, Suite 300
St. Louis, MO 63110
Tel: 314-429-0100
fax: 314-429-0462

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Applied Chemistry. Creative Solutions

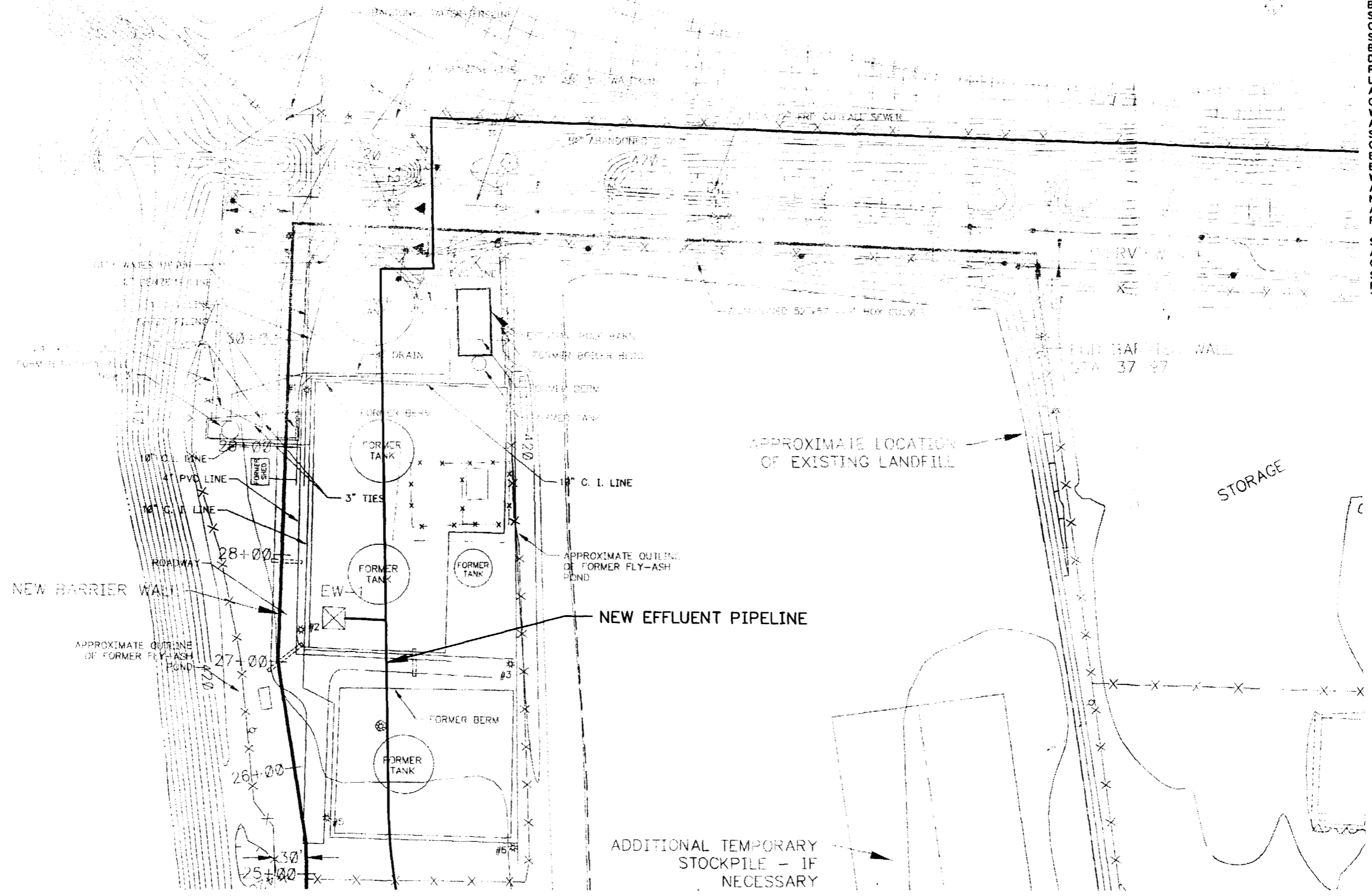
SOLUTIA INC.
575 MARYVILLE CENTRE DRIVE
ST. LOUIS, MO. 63141

GROUNDWATER MIGRATION CONTROL SYSTEM	PROJECT NO. 21561192.00001
PACKAGE 2 - BARRIER WALL	
BORING LOCATION PLAN	SHEET NO. 2-05

NOTE:

EXISTING SURFACE FEATURES HAVE BEEN PLOTTED FROM AN AERIAL SURVEY BY SURDEX. THE LOCATIONS OF UNDERGROUND UTILITIES, STRUCTURES AND FACILITIES HAVE BEEN PLOTTED FROM PLANS AND DRAWINGS OF EXISTING FACILITIES PROVIDED BY Solutia. THEIR LOCATIONS MUST BE CONSIDERED APPROXIMATE ONLY. THERE MAY BE OTHER IMPROVEMENTS AND UTILITIES WITHIN THE PROJECT AREA, WHICH ARE NOT SHOWN. THE CONTRACTOR SHALL VERIFY, PRIOR TO EXCAVATION OR CONSTRUCTION, THE LOCATIONS, ELEVATIONS AND DIMENSIONS OF ALL EXISTING UTILITIES, STRUCTURES, WELLS AND OTHER FEATURES AFFECTING HIS WORK, WHETHER OR NOT SHOWN ON THE PLANS. USE OF A SUBSURFACE LOCATOR IS RECOMMENDED.

SHOULD ANY FEATURE ADVERSELY AFFECT THE PROPOSED CONSTRUCTION, THE CONTRACTOR SHALL OBTAIN Solutia's APPROVAL FOR A CHANGE OR MODIFICATION TO THESE PLANS PRIOR TO PROCEEDING.



P:\E\1581192\0000\FINAL DESIGN 7-3-03\SHEETS 2-04-06-08-14.DWG Last edited: JUL 02 09 44:48 a.m. by: D:\D0000

NO.	DATE	REVISION DESCRIPTION	APPROVED



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St. Louis, MO 63110**

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SEAL

DATE: 7/3/03


SCALE: AS SHOWN

DESIGNED: MJB

DRAWN: DIB/YDL

CHECKED: MJB

SUBMITTED:



Solutia INC.
575 MARYVILLE CENTRE DRIVE
ST. LOUIS, MO. 63141

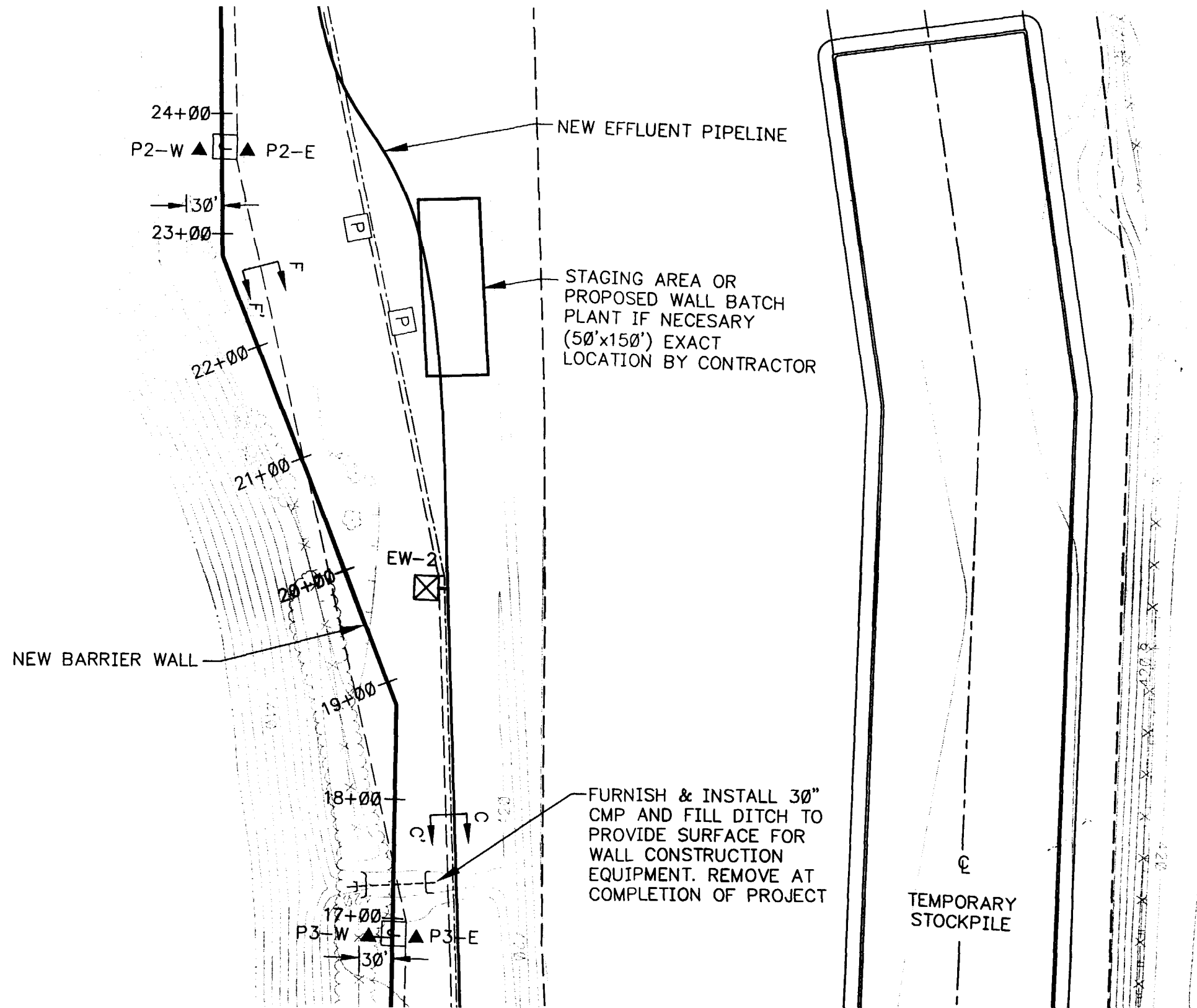
Applied Chemistry, Creative Solutions

GROUNDWATER MIGRATION CONTROL SYSTEM		PROJECT NO.
EFFLUENT PIPELINE		21561192.00001
SITE PLAN - NORTH		SHEET NO.
		2-06

NOTE:

EXISTING SURFACE FEATURES HAVE BEEN PLOTTED FROM AN AERIAL SURVEY BY SURDEX. THE LOCATIONS OF UNDERGROUND UTILITIES, STRUCTURES AND FACILITIES HAVE BEEN PLOTTED FROM PLANS AND DRAWINGS OF EXISTING FACILITIES PROVIDED BY Solutia. THEIR LOCATIONS MUST BE CONSIDERED APPROXIMATE ONLY. THERE MAY BE OTHER IMPROVEMENTS AND UTILITIES WITHIN THE PROJECT AREA, WHICH ARE NOT SHOWN. THE CONTRACTOR SHALL VERIFY, PRIOR TO EXCAVATION OR CONSTRUCTION, THE LOCATIONS, ELEVATIONS AND DIMENSIONS OF ALL EXISTING UTILITIES, STRUCTURES, WELLS AND OTHER FEATURES AFFECTING HIS WORK, WHETHER OR NOT SHOWN ON THE PLANS. USE OF A SUBSURFACE LOCATOR IS RECOMMENDED.

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FILE: E:\21561192\0001\12-18-03 PWA\SITE PLANS\DWG Unit without A.L. 01, 03 & 321 p.m. by: DJR2230

NO.	DATE	REVISION DESCRIPTION	APPROVED

PREPARED BY:

URS

1001 Highlands Plaza Dr. West, Suite 300
St. Louis, MO 63110
Tel: 314-429-0100
Fax: 314-429-0462

SEAL

DATE: 6/25/03
SCALE: AS SHOWN
DESIGNED: MJS
DRAWN: BJD/WDL
CHECKED: MJS
SUBMITTED:



Solutia Inc.
575 Maryville Centre Drive
St. Louis, MO. 63141

Applied Chemistry. Creative Solutions

GROUNDWATER MIGRATION CONTROL SYSTEM		PROJECT NO.
PACKAGE 2 - BARRIER WALL		21561192.00001
SITE PLAN - MIDDLE		SHEET NO.
		2-07

NOTE:

EXISTING SURFACE FEATURES HAVE BEEN PLOTTED FROM AN AERIAL SURVEY BY SURDEX. THE LOCATIONS OF UNDERGROUND UTILITIES, STRUCTURES AND FACILITIES HAVE BEEN PLOTTED FROM PLANS AND DRAWINGS OF EXISTING FACILITIES PROVIDED BY SOLUTIA. THEIR LOCATIONS MUST BE CONSIDERED APPROXIMATE ONLY. THERE MAY BE OTHER IMPROVEMENTS AND UTILITIES WITHIN THE PROJECT AREA, WHICH ARE NOT SHOWN. THE CONTRACTOR SHALL VERIFY, PRIOR TO EXCAVATION OR CONSTRUCTION, THE LOCATIONS, ELEVATIONS AND DIMENSIONS OF ALL EXISTING UTILITIES, STRUCTURES, WELLS AND OTHER FEATURES AFFECTING HIS WORK, WHETHER OR NOT SHOWN ON THE PLANS. USE OF A SUBSURFACE LOCATOR IS RECOMMENDED.

SHOULD ANY FEATURE ADVERSELY AFFECT THE PROPOSED CONSTRUCTION, THE CONTRACTOR SHALL OBTAIN SOLUTIA'S APPROVAL FOR A CHANGE OR MODIFICATION TO THESE PLANS PRIOR TO PROCEEDING.

NEW BARRIER WALL

NEW EFFLUENT PIPELINE

TEMPORARY STOCKPILE

BEGIN BARRIER WALL STA. 5+00

FURNISH & INSTALL 30" CMP AND FILL DITCH TO PROVIDE SURFACE FOR WALL CONSTRUCTION EQUIPMENT. REMOVE AT COMPLETION OF PROJECT

16+00

15+00

14+00

13+00

12+00

11+00

10+00

9+00

8+00

7+00

6+00

5+00

4+00

3+00

2+00

1+00

0+00

25'

EW-3

20' Min.

20' Min.

20' Min.

20' Min.

20' Min.

20' Min.

20' Min.

20' Min.

20' Min.

20' Min.

20' Min.

SCALE 50 FEET

URS

1001 Highlands Plaza Dr. West, Suite 300
St. Louis, MO 63110

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SEAL

DATE: 7/3/03

SCALE: AS SHOWN

DESIGNED: MJB

DRAWN: JND/WDL

CHECKED: MJB

SUBMITTED:



SOLUTIA INC.
575 MARYVILLE CENTRE DRIVE
ST. LOUIS, MO. 63141

Applied Chemistry, Creative Solutions

GROUNDWATER MIGRATION CONTROL SYSTEM

EFFLUENT PIPELINE

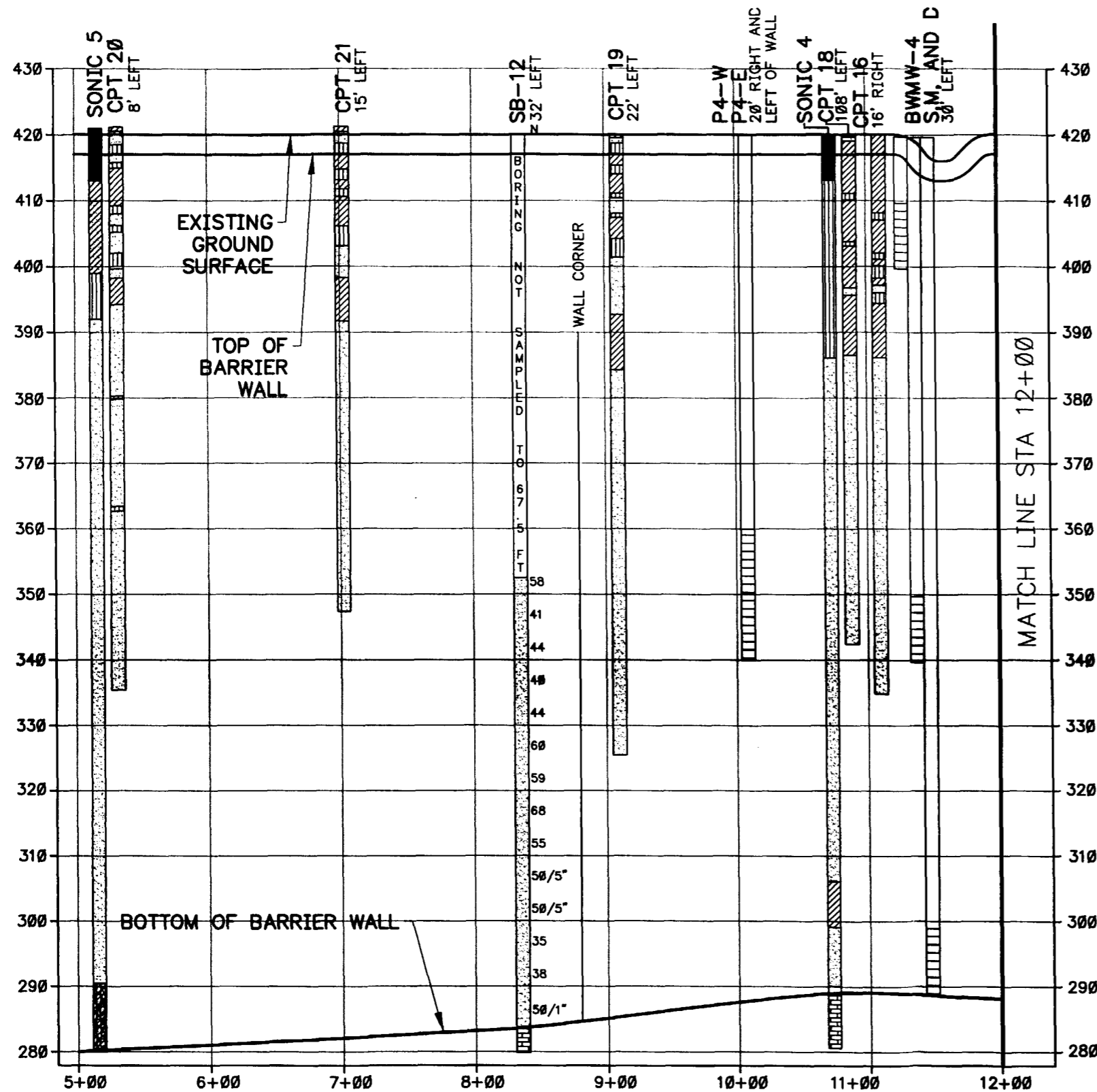
SITE PLAN - SOUTH

PROJECT NO.

21561192.00001

SHEET NO.

2-08

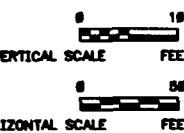


LEGEND

- CLAY (CL OR CH)
- SILT (ML)
- CLAYEY SAND (SC)
- SAND (SP OR SW)
- GRAVEL AND/OR COBBLES
- LIMESTONE
- PROPOSED SCREENED INTERVAL OF EXTRACTION WELL OR PIEZOMETER
- 10+00 WALL STATION AT CENTERLINE OF BARRIER WALL
- CPT-1 CONE PENETROMETER TEST NUMBER (2001)
- SONIC 1 SONIC BORING NUMBER (2002)
- SB-1 SOIL BORING NUMBER (2002)
- 62 STANDARD PENETRATION TEST BLOW COUNT (N). BLOWS /12" PENETRATION OF SAMPLER UNLESS INDICATED OTHERWISE
- P HYDRAULICALLY PUSHED SAMPLE

NOTES:

- 1) THESE GRAPHIC LOGS DEPICT GENERALIZED SOIL CONDITIONS. REFER TO INDIVIDUAL LOGS FOR DETAILS.
- 2) TOP AND BOTTOM OF BARRIER WALL AS SHOWN ARE APPROXIMATE. ACTUAL LOCATIONS ARE SUBJECT TO CHANGE DUE TO DESIGN AND CONSTRUCTION ISSUES.



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NO.	DATE	REVISION DESCRIPTION	APPROVED

PREPARED BY:

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fax: 314-429-0462

SEAL

DATE: 7/3/06
SCALE: AS SHOWN
DESIGNED: KMB
DRAWN: JJD/VOL
CHECKED: KMB
SUBMITTED:



SOLUTIA INC.
575 MARYVILLE CENTRE DRIVE
ST. LOUIS, MO. 63141

GROUNDWATER MIGRATION CONTROL SYSTEM

PACKAGE 2 - BARRIER WALL

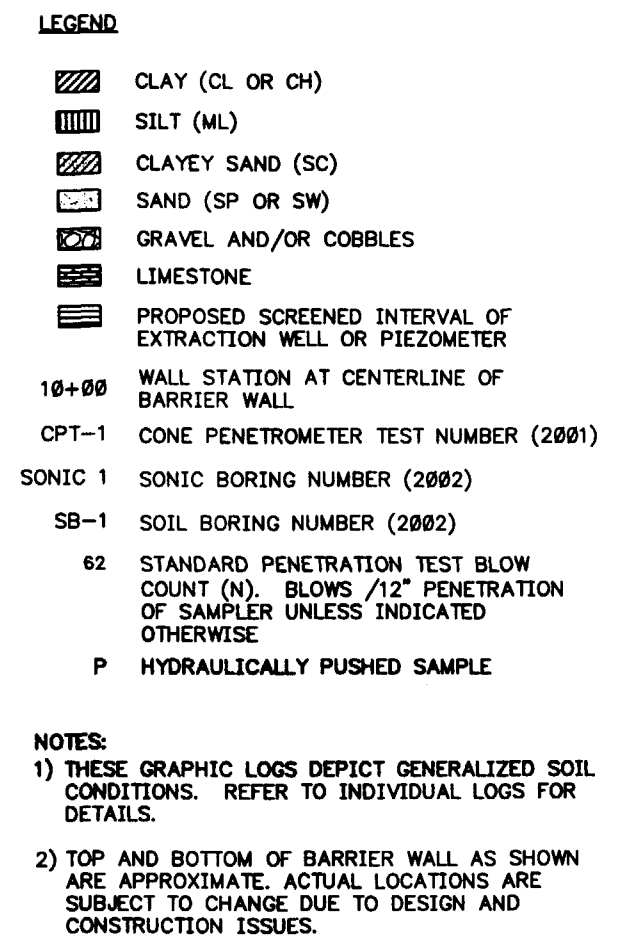
BARRIER WALL - PROFILE
STA 5+00 TO 12+00

URS PROJECT NO.

21561192.00001

SHEET NO.

2-09

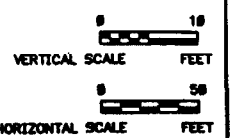
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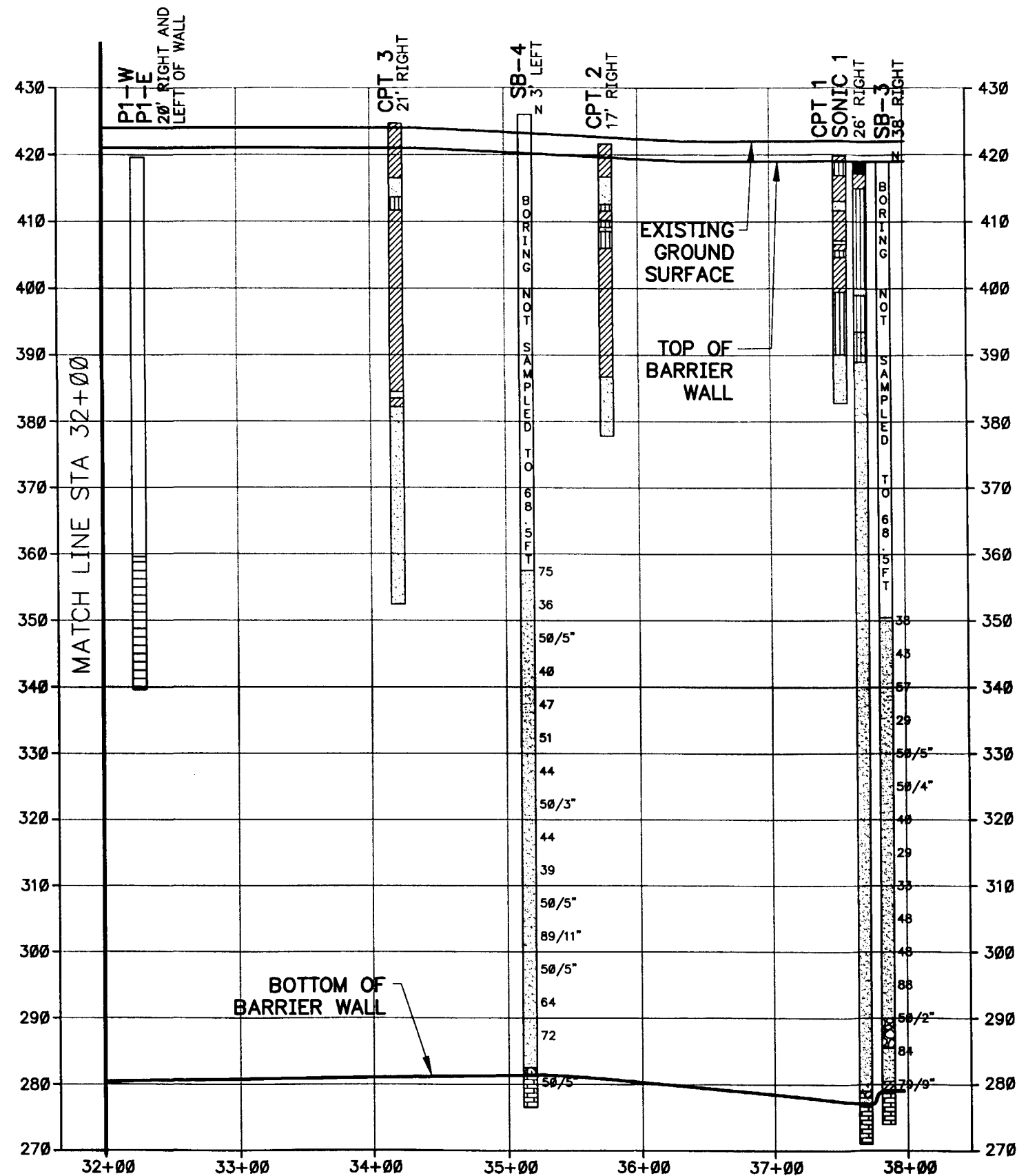
DATE: 7/3/03
SCALE: AS SHOWN
DESIGNED: EMB
DRAWN: DJD/WDL
CHECKED: EMB
SUBMITTED:

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Applied Chemistry. Creative Solutions

SOLUTIA INC.
575 MARYVILLE CENTRE DRIVE
ST. LOUIS, MO. 63141

GROUNDWATER MIGRATION CONTROL SYSTEM		URS PROJECT NO.
PACKAGE 2 - BARRIER WALL		21561192.00001
BARRIER WALL - PROFILE STA 21+50 TO 32+00		SHEET NO. 2-11



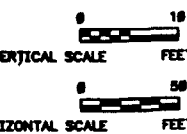


LEGEND

- CLAY (CL OR CH)
- SILT (ML)
- CLAYEY SAND (SC)
- SAND (SP OR SW)
- GRAVEL AND/OR COBBLES
- LIMESTONE
- PROPOSED SCREENED INTERVAL OF EXTRACTION WELL OR PIEZOMETER
- 10+00 WALL STATION AT CENTERLINE OF BARRIER WALL
- CPT-1 CONE PENETROMETER TEST NUMBER (2001)
- SONIC 1 SONIC BORING NUMBER (2002)
- SB-1 SOIL BORING NUMBER (2002)
- 62 STANDARD PENETRATION TEST BLOW COUNT (N). BLOWS /12" PENETRATION OF SAMPLER UNLESS INDICATED OTHERWISE
- P HYDRAULICALLY PUSHED SAMPLE

NOTES:

- 1) THESE GRAPHIC LOGS DEPICT GENERALIZED SOIL CONDITIONS. REFER TO INDIVIDUAL LOGS FOR DETAILS.
- 2) TOP AND BOTTOM OF BARRIER WALL AS SHOWN ARE APPROXIMATE. ACTUAL LOCATIONS ARE SUBJECT TO CHANGE DUE TO DESIGN AND CONSTRUCTION ISSUES.



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NO.	DATE	REVISION DESCRIPTION	APPROVED

PREPARED BY:

URS

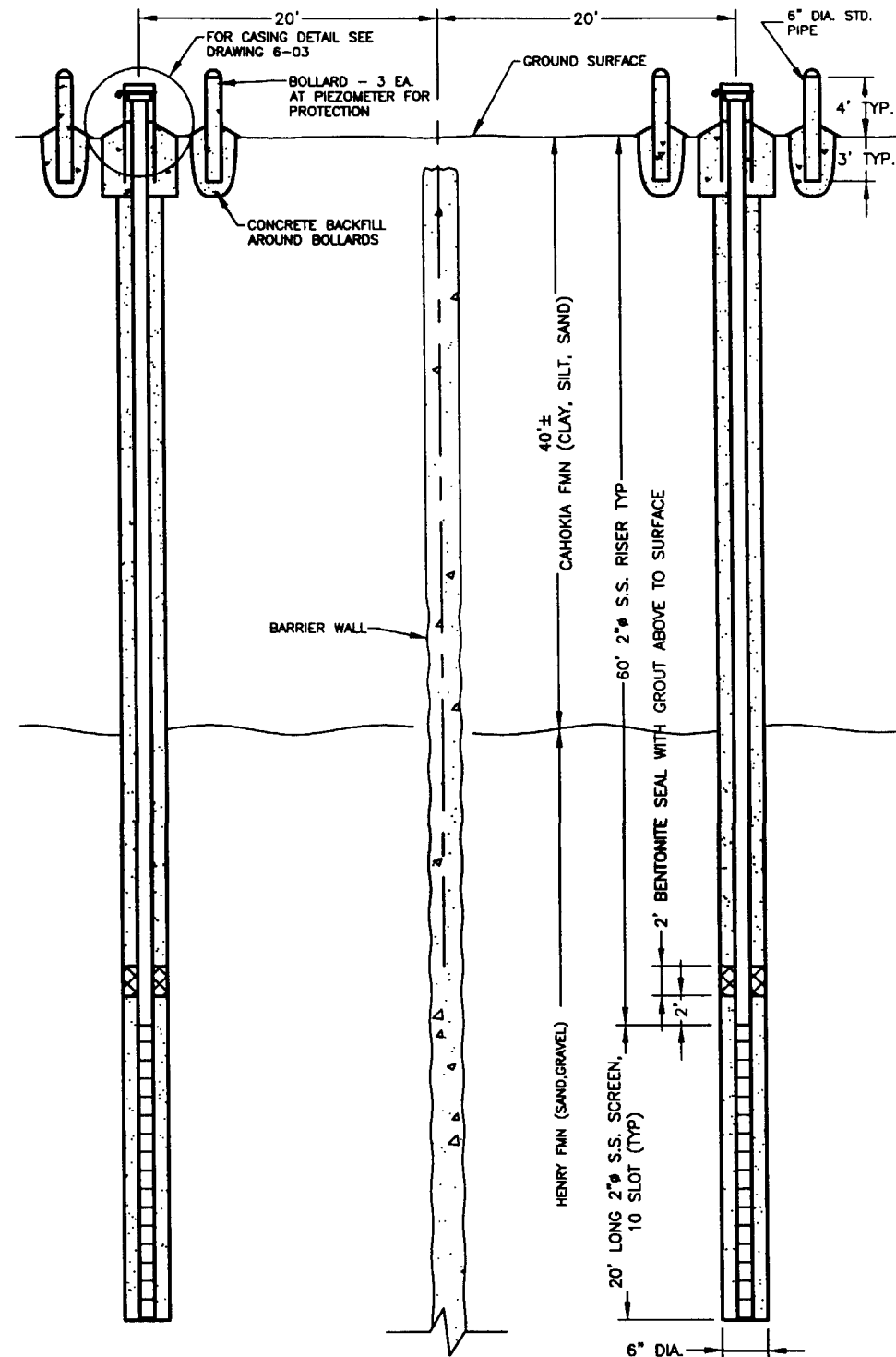
1001 Highlands Plaza Dr. West, Suite 300
St. Louis, MO 63110
Tel: 314-429-0100
Fax: 314-429-0462

DATE: 7/3/03
SCALE: AS SHOWN
DESIGNED: KMB
DRAWN: BMD/VBL
CHECKED: KMB
SUBMITTED:

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Applied Chemistry, Creative Solutions

SOLUTIA INC.
575 MARYVILLE CENTRE DRIVE
ST. LOUIS, MO. 63141

GROUNDWATER MIGRATION CONTROL SYSTEM	URS PROJECT NO.
PACKAGE 2 - BARRIER WALL	21561192.00001
BARRIER WALL - PROFILE STA 32+00 TP 37+97	SHEET NO. 2-12



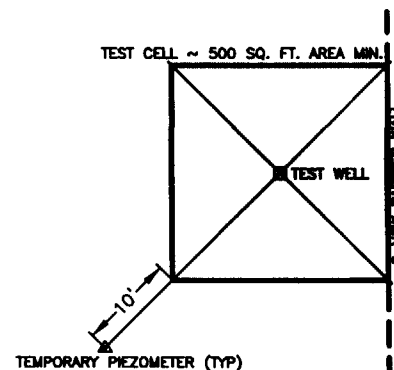
TYPICAL PERMANENT PIEZOMETER ARRANGEMENT
FOR PIEZOMETER PAIRS AT BARRIER WALL

NOT TO SCALE

Barrier Wall Layout Table						
Station	Northing (ft.)	Easting (ft.)	Ground Elevation (ft.)	Top of Wall (ft.)	Bottom of Wall* (ft.)	Top of Rock* (ft.)
5+00	702134.45	2290657.77	420	417	280	280
8+80	702321.24	2290326.81	420	417	285	285
11+28	702514.76	2290172.6	420	417	288	288
18+79	703176.36	2290529.57	420	417	287	287
22+81	703575.91	2290573.45	420	417	289	289
25+29	703797.03	2290685.51	421	418	287	287
27+00	703962.00	2290740.07	422	419	287	287
31+08	704315.56	2290939.85	423	420	287	287
37+97	703979.41	2291539.83	422	419	279	279

* ELEVATION IS ESTIMATED. ACTUAL ELEVATIONS TO BE FIELD DETERMINED

Permanent Piezometer Layout Table					
Piezometer	Northing (ft.)	Easting (ft.)	Ground Elevation (ft.)	Tip Elevation (ft.)	Top of Screen (ft.)
P1-W	704281.97	2290898.03	423	343	363
P1-E	704263.00	2290933.33	423	343	363
P2-W	703664.78	2290597.35	420	340	360
P2-E	703645.81	2290632.65	420	340	360
P3-W	703015.76	2290419.97	423	343	363
P3-E	702996.78	2290455.27	423	343	363
P4-W	702533.45	2290160.17	420	340	360
P4-E	702514.47	2290195.47	420	340	360

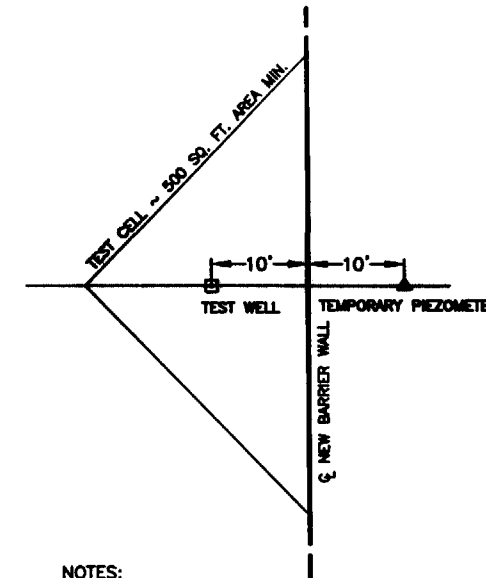


NOTES:

1. INSTALL TEST CELL USING SAME MIX DESIGN AND CONSTRUCTION PROCEDURES AS PROPOSED FOR PRODUCTION BARRIER WALL.
2. INSTALL TEST CELL PRIOR TO INSTALLATION OF PRODUCTION BARRIER WALL.
3. PIEZOMETER EXTENDS TO 80 FEET BELOW GRADE, SCREENED IN BOTTOM 20 FEET.
4. TEST WELL DESIGN PER CONTRACTOR.

TYPICAL TEST ARRANGEMENT AT
BARRIER WALL
PRE PRODUCTION TEST CELL
IF NECESSARY

SCALE 1"=10'

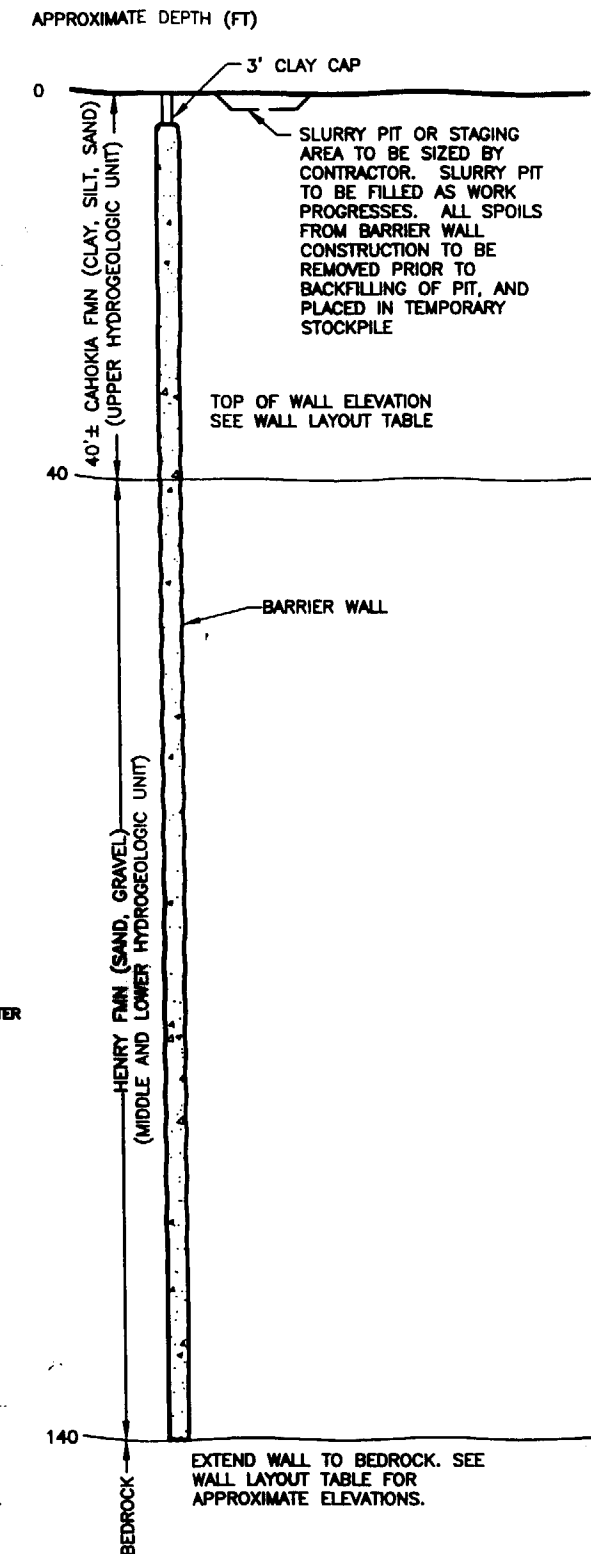


NOTES:

1. INSTALL TEST CELL USING SAME MIX DESIGN AND CONSTRUCTION PROCEDURES AS PRODUCTION BARRIER WALL.
2. PIEZOMETER EXTEND TO 80 FEET BELOW GRADE, SCREENED IN BOTTOM 20 FEET.
3. TEST WELL DESIGN PER CONTRACTOR.

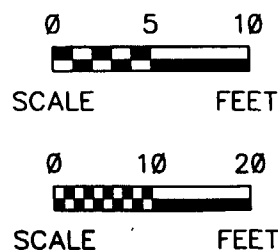
TYPICAL TEST ARRANGEMENT AT
BARRIER WALL
PRODUCTION TEST CELL
IF NECESSARY

SCALE 1"=10'



BARRIER WALL DETAIL

NOT TO SCALE



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NO.	DATE	REVISION DESCRIPTION	APPROVED

PREPARED BY:

URS

1001 Highlands Plaza Dr. West, Suite 300
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Tel: 314-429-0100
Fax: 314-429-0462

SEAL

DATE: 7/3/03
SCALE: AS SHOWN
DESIGNED: KMB
DRAWN: DJD
CHECKED: KMB
SUBMITTED:

SOLUTIA
Applied Chemistry, Creative Solutions

SOLUTIA INC.
575 MARYVILLE CENTRE DRIVE
ST. LOUIS, MO. 63141

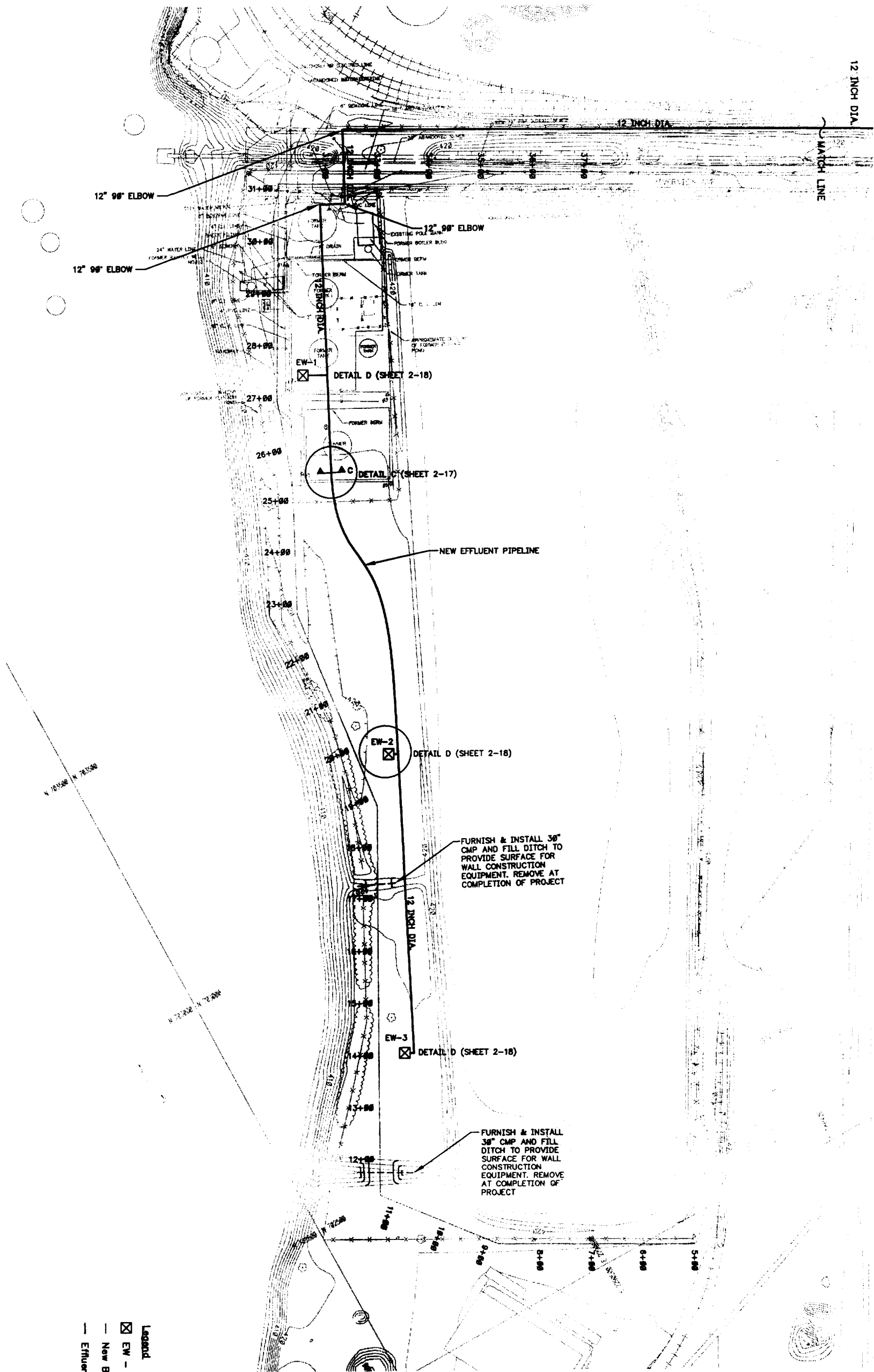
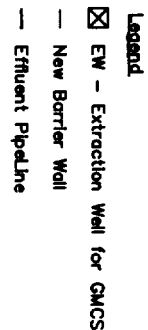
GROUNDWATER MIGRATION CONTROL SYSTEM	URS PROJECT NO.
PACKAGE 2 - BARRIER WALL	2161192.00001
BARRIER WALL DETAILS	SHEET NO.
	2-13

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DATE: 7/3/03
SCALE: AS SHOWN
DESIGNED: GDS
DRAWN: DLD/VDL
CHECKED: GDS
SUBMITTED:

SEA

GROUNDWATER MIGRATION CONTROL SYSTEM	PROJECT NO.
EFFLUENT PIPELINE	21661192.0000
PLAN OF EFFLUENT PIPELINE (WEST)	SHEET NO.
	2-14



EXISTING SURFACE FEATURES HAVE BEEN PLOTTED FROM AN AERIAL SURVEY BY SUREX. THE LOCATIONS OF UNDERGROUND UTILITIES, STRUCTURES AND FACILITIES HAVE BEEN PLOTTED FROM PLANS AND DRAWINGS OF EXISTING FACILITIES PROVIDED BY SOUTHA. THEIR LOCATIONS MUST BE CONSIDERED APPROXIMATE ONLY. THERE MAY BE OTHER IMPROVEMENTS AND UTILITIES WITHIN THE PROJECT AREA, WHICH ARE NOT SHOWN. THE CONTRACTOR SHALL VERIFY, PRIOR TO EXCAVATION OR CONSTRUCTION, THE LOCATIONS, ELEVATIONS AND DIMENSIONS OF ALL EXISTING UTILITIES, STRUCTURES, WELLS AND OTHER FEATURES AFFECTING HIS WORK, WHETHER OR NOT SHOWN ON THE PLANS. USE OF A SUBSURFACE LOCATOR IS RECOMMENDED.

SHOULD ANY FEATURE ADVERSELY AFFECT THE PROPOSED CONSTRUCTION, THE CONTRACTOR SHALL OBTAIN SOUTHA'S APPROVAL FOR A CHANGE OR MODIFICATION TO THESE PLANS PRIOR TO PROCEEDING.

FOR PIPE ELEVATION SEE DWG 2-16.

NOTE:

EXISTING SURFACE FEATURES HAVE BEEN PLOTTED FROM AN AERIAL SURVEY BY SURDEX. THE LOCATIONS OF UNDERGROUND UTILITIES, STRUCTURES AND FACILITIES HAVE BEEN PLOTTED FROM PLANS AND DRAWINGS OF EXISTING FACILITIES PROVIDED BY Solutia. THEIR LOCATIONS MUST BE CONSIDERED APPROXIMATE ONLY. THERE MAY BE OTHER IMPROVEMENTS AND UTILITIES WITHIN THE PROJECT AREA, WHICH ARE NOT SHOWN. THE CONTRACTOR SHALL VERIFY, PRIOR TO EXCAVATION OR CONSTRUCTION, THE LOCATIONS, ELEVATIONS AND DIMENSIONS OF ALL EXISTING UTILITIES, STRUCTURES, WELLS AND OTHER FEATURES AFFECTING HIS WORK, WHETHER OR NOT SHOWN ON THE PLANS. USE OF A SUBSURFACE LOCATOR IS RECOMMENDED.

SHOULD ANY FEATURE ADVERSELY AFFECT THE PROPOSED CONSTRUCTION, THE CONTRACTOR SHALL OBTAIN Solutia's APPROVAL FOR A CHANGE OR MODIFICATION TO THESE PLANS PRIOR TO PROCEEDING.

ELECTRICAL NOTES:

- E1** PROVIDE 1-INCH HEAVY WALL HDPE-SR13.5 CONDUIT INSTALLED ALONGSIDE NEW 12-INCH EFFLUENT PIPE FOR FLOWMETER ANALOG WIRING. REFER TO DRAWING 2-20P FOR FLOWMETER LOCATION AND WIRING REQUIREMENTS.
- E2** PROVIDE 24" X 30" X 24" DEEP QUARTZITE OPEN-BOTTOM PULLBOX FLUSH WITH GRADE AND GRAVEL DRAINAGE PER MANUFACTURER RECOMMENDATIONS. INSTALL CONDUITS (NOTES E1 AND E3) INTO BOTTOM OF PULLBOX USING WIDE-SWEEP BENDS. LOOP ANALOG CABLE FROM FLOWMETER TO PLC THROUGH PULLBOX, LEAVING SLACK IN THE CABLE.
- E3** PROVIDE 1-INCH CONDUIT, SAME AS NOTE E1, AT LEAST 36-INCHES UNDERGROUND FROM PULLBOX TO NORTHWEST CORNER OF STRUCTURE.
- E4** TRANSITION UNDERGROUND CONDUIT TO 1-INCH ROB ROY PVC-COATED RIGID CONDUIT AND EXTEND UP ON CONCRETE STRUCTURE. INSTALL ON WALL USING EXISTING STRUT, SUPPLEMENTED AS REQUIRED WITH ADDITIONAL CONDUIT SUPPORTS, TO PLC CABINET.
- E5** EXTEND CONDUIT UP INTO BOTTOM OF EXISTING PLC CABINET. PROVIDE WIRING FROM FLOWMETER AT PUMP DISCHARGE TO OWNER-PROVIDED ANALOG PLC INPUT CARD IN CABINET AND MAKE CONNECTIONS.

Legend

- Effluent Pipeline
 Y Reducer
 * Plug Valve (Buried)

SCALE 1" = 100' FEET

SCALE 1" = 20' FEET

FILE: E:\21561192.00001\FINAL DESIGN 7-3-03 SHEETS 2-15.DWG Last updated: JUL 02, 03 @ 3:29 p.m. by: DUREGARD

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 DRAWN: BJD/VDL
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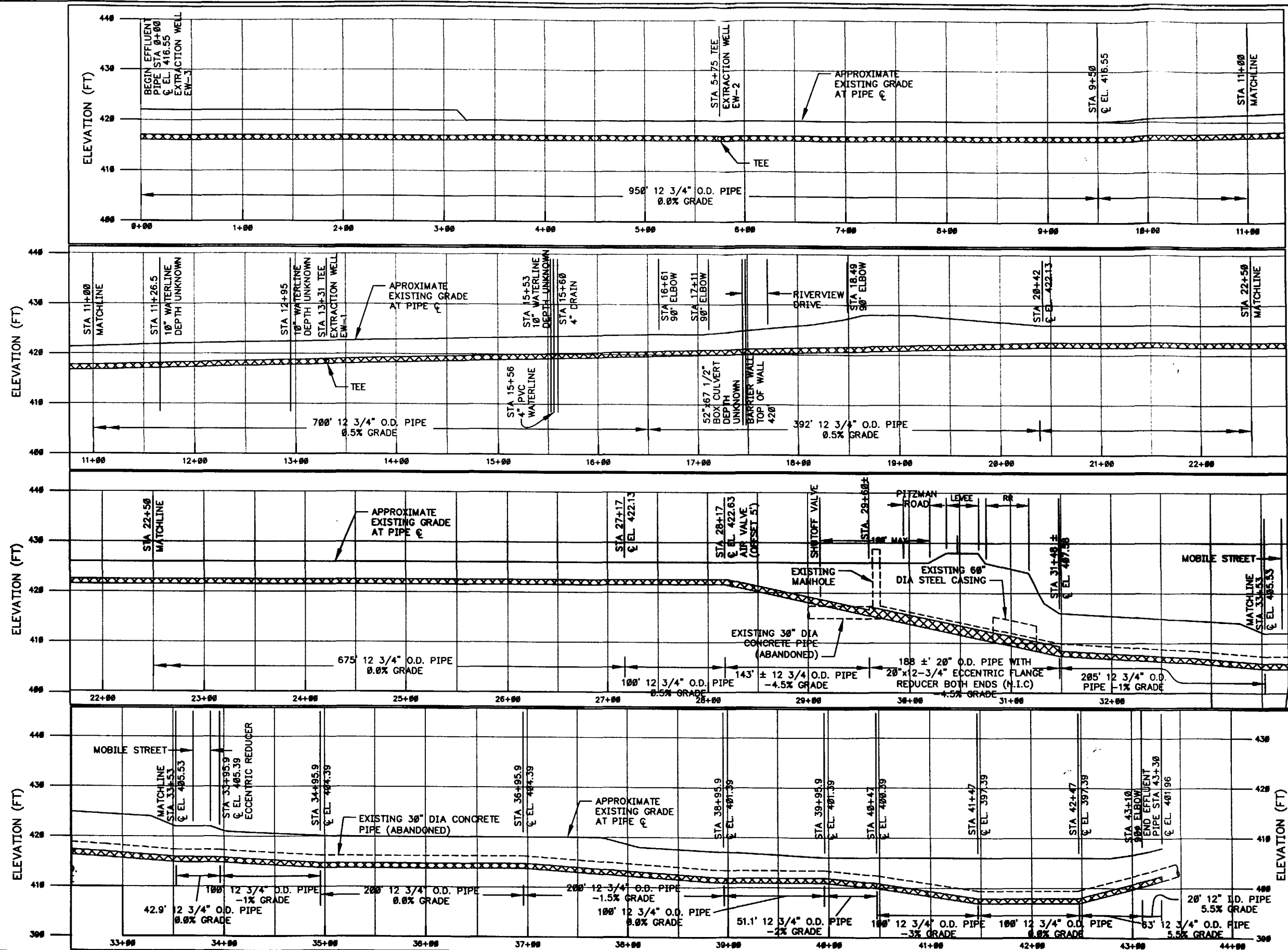


Solutia INC.
 575 MARYVILLE CENTRE DRIVE
 ST. LOUIS, MO. 63141

Applied Chemistry, Creative Solutions

GROUNDWATER MIGRATION CONTROL SYSTEM		PROJECT NO.
EFFLUENT PIPELINE		21561192.00001
PLAN OF GROUNDWATER DISCHARGE LINE (EAST)		SHEET NO.
		2-15

FILE: E:\21501192.00001\FINAL DESIGN 7-5-03 SHEET 2-16.DWG Last edited: JUL 02 03 @ 12:55 P.M. BY: DAEGLUO



NOTES:

- 1) REMOVE EXISTING 6-IN. DIA. SULFURIC ACID CARRIER PIPE AND 12-IN. DIA. STEEL CASING PIPE AND SLIP 20-IN. OD HDPE PIPE INTO EXISTING 30-IN. ID ABANDONED REINFORCED CONCRETE WATER PIPE AT ABOUT STA 29+60 AND EXTEND TO STA 43+10. IT MAY BE NECESSARY TO EXCAVATE AT INTERMEDIATE LOCATIONS TO ACCOMPLISH THE SLIPLINING. (SEE REFERENCE DRAWINGS).
- 2) GROUT ANNULUS BETWEEN 20-IN. DIAMETER HDPE PIPE AND ID OF 30-IN. DIAMETER RCP FROM AT LEAST STA 29+60± TO STA 31+48. INSTALL SUFFICIENT CENTERING GUIDES TO ASSURE UNIFORM ANNULAR GROUT THICKNESS IN THIS REACH. DEVELOP AND SUBMIT DESIGN OF PACKER TO CONTAIN GROUT AT STA 31+48.
- 3) DEMOLISH EXISTING 30-IN. VALVE MANHOLE AND 30-IN. PIPE AT SUCH LOCATIONS NECESSARY TO INSTALL HDPE LINE. LOAD AND HAUL DEMOLITION DEBRIS TO TEMPORARY STOCKPILE.
- 4) GRADES OF THE EXISTING ABANDONED 30-IN. DIAMETER REINFORCED CONCRETE PIPE ARE BASED ON THE FOLLOWING REFERENCE DRAWINGS AND ADDING 312.36 FT TO THE ELEVATIONS SHOWN ON THE REFERENCE DRAWINGS TO CONVERT THEM TO FT, NGVD:

A. MONSANTO CHEMICAL CO. DWG D-13054, REV. 4, 4/19/54
B. MONSANTO CHEMICAL CO. DWG D-13055, REV. 4, 4/19/54
C. MONSANTO CHEMICAL CO. DWG D-13056, REV. 4, 4/19/54
D. MONSANTO CHEMICAL CO. DWG D-13057, REV. 6, 5/7/54
E. MONSANTO CHEMICAL CO. DWG D-13059, REV. 4, 5/19/54
F. MONSANTO CHEMICAL CO. DWG D-13060, REV. 2, 1/21/54
- 5) OTHER REFERENCE DRAWINGS
A. MONSANTO COMPANY DRAWING TS-B-15062, REV. 2, 9/18/79
B. MONSANTO COMPANY DRAWING TS-D-15071, REV. 8, 9/8/79
- 6) THE DRAWINGS SHOW THE PIPELINE WITHIN THE EXISTING 30-IN. DIA RCP FROM ABOUT STA 29+60 TO STA 43+10. THE PIPELINE SHALL BE WITHIN THE RCP AS A MINIMUM UNDER THE LEVEE AND RAILROAD TRACKS (APPROXIMATELY STA 29+60 TO STA 31+48). AT OTHER LOCATIONS, THE PIPELINE MAY BE INSTALLED EITHER IN THE 30-IN. RCP OR IN ITS OWN TRENCH ALONGSIDE THE 30-IN. RCP. CONTRACTOR SHALL FURNISH AND INSTALL THE NECESSARY HDPE FITTINGS TO ACCOMPLISH TRANSITIONS IN THE LOCATION OF THE PIPELINE EITHER WITHIN OR OUTSIDE OF THE 30-IN. RCP.
- 7) THE 20-IN. OD PIPE UNDER THE LEVEE AND RAILROAD TRACKS WILL BE INSTALLED UNDER ANOTHER CONTRACT. THIS CONTRACT INCLUDES FURNISHING AND INSTALLING THE NECESSARY PIPE FITTINGS TO REDUCE FROM 20 IN. O.D. TO 12.75 IN. O.D. BOTH UPSTREAM AND DOWNSTREAM OF THE 20 IN. O.D. PIPE UNDER THE LEVEE AND RAILROAD TRACKS HAS BEEN INSTALLED UNDER ANOTHER CONTRACT. THIS CONTRACT INCLUDES FURNISHING AND INSTALLING THE NECESSARY PIPE FITTINGS TO REDUCE FROM 20-IN. O.D. TO 12.75-IN. O.D. BOTH UPSTREAM AND DOWNSTREAM OF THE 20-IN. O.D. PIPE.
- 8) FURNISH AND INSTALL 12-IN. PLUG VALVE IN LINE NOT MORE THAN 100 FT. RIVERWARD OF RIVERSIDE TOE OF LEVEE.
- 9) CONSTRUCT MANHOLE FOR COMBINATION AIR VALVE AT HIGH POINT IN PIPELINE.

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DRAWN: DWD/WDL
CHECKED: GRS
SUBMITTED:



SOLUTIA INC.
575 MARYVILLE CENTRE DRIVE
ST. LOUIS, MO. 63141

Applied Chemistry, Creative Solutions

GROUNDWATER MIGRATION CONTROL SYSTEM

EFFLUENT PIPELINE

PROFILE OF EFFLUENT PIPELINE

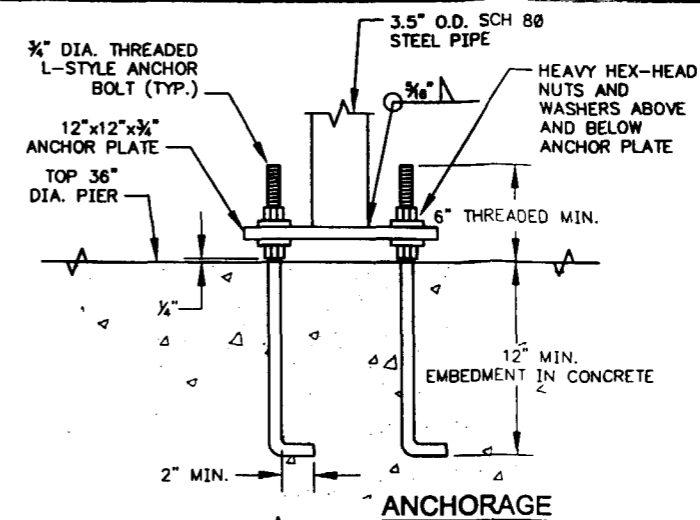
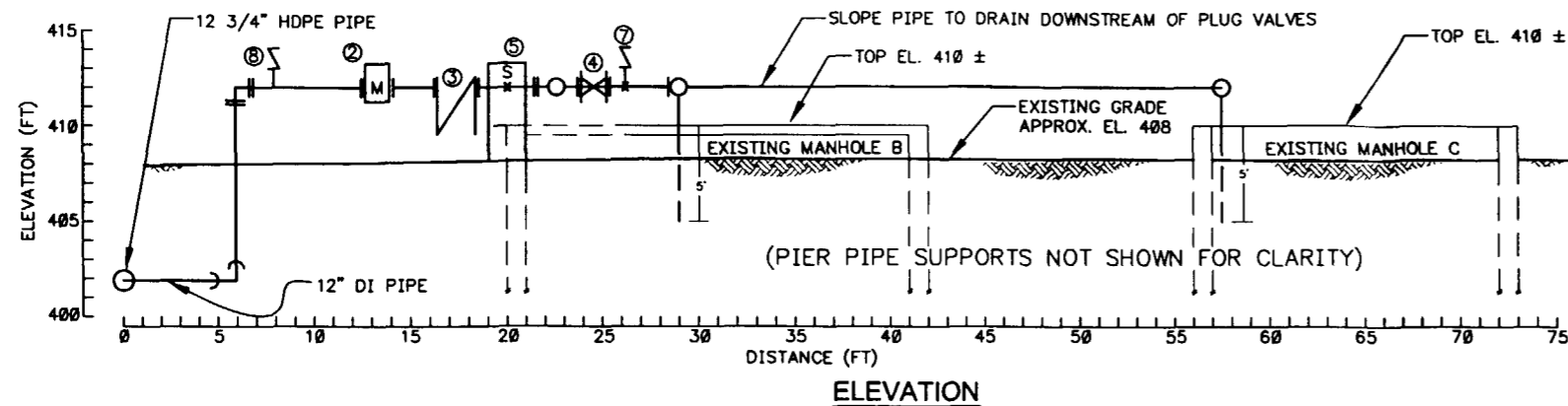
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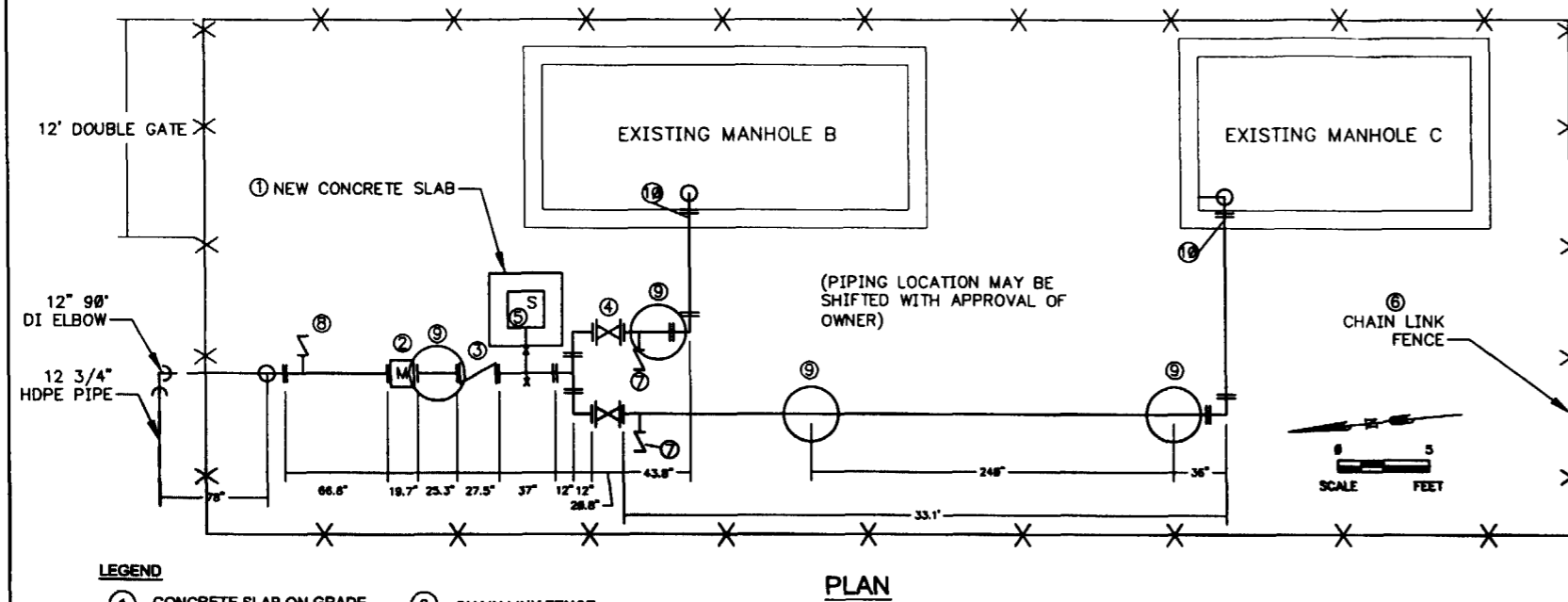
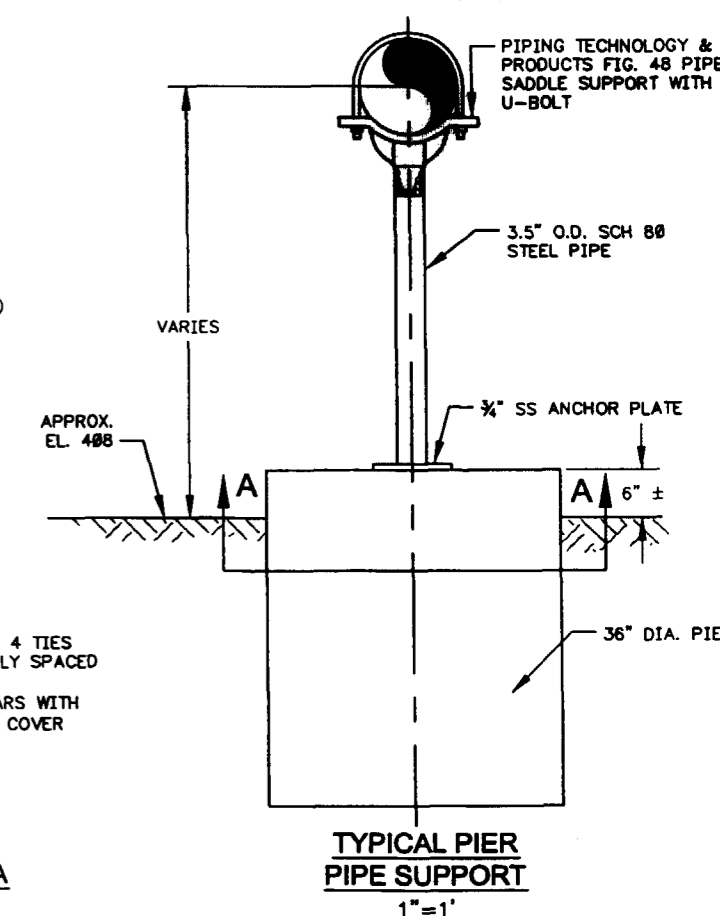
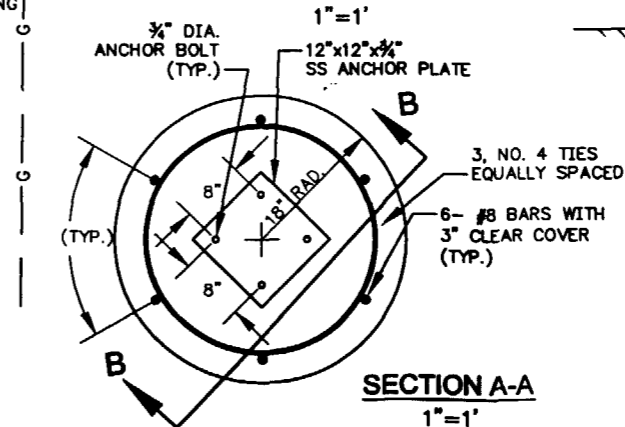
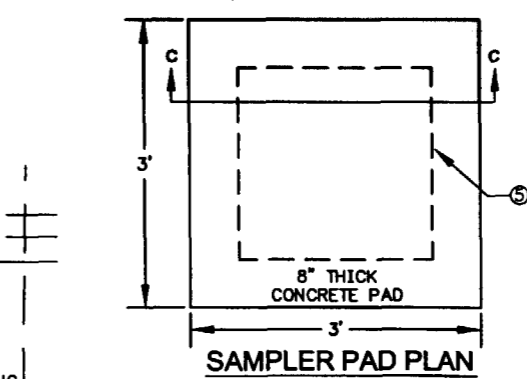
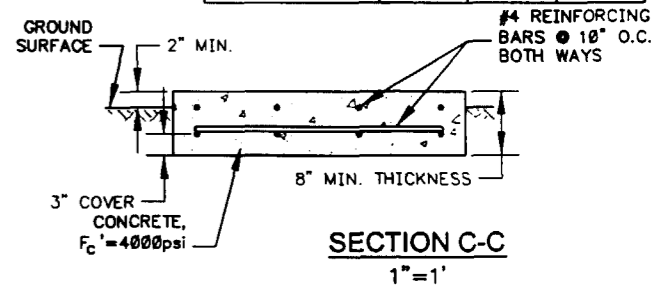
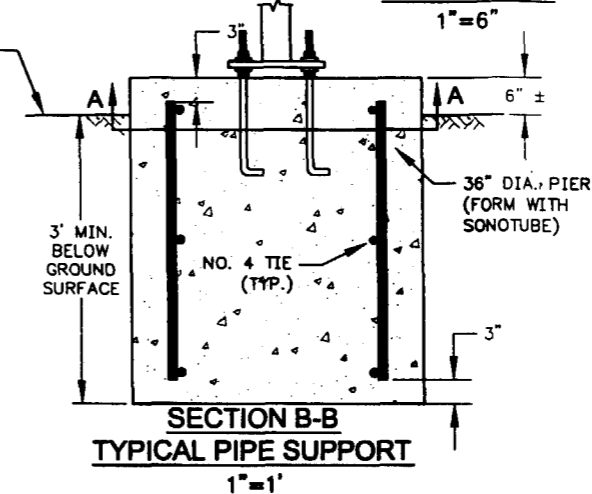
SHEET NO.

2-16

NOTE: CONTRACTOR SHALL SET ELEVATION OF PIPING TO CLEAR TOP OF MANHOLES B AND C.



	FLANGED	SCREWED	BELL & SPIG
JOINT			
ELBOW 90 DEG.			
ELBOW 45 DEG.			
ELBOW TURNED UP			
ELBOW TURNED DOWN			
TEE			
TEE-OUTLET UP			
TEE-OUTLET DOWN			
GATE VALVE			
CHECK VALVE			
REDUCER			



LEGEND

- | | |
|--|---------------------------|
| ① CONCRETE SLAB ON GRADE | ⑥ CHAIN LINK FENCE |
| ② 12\" MAGNETIC FLOW METER (FURNISHED BY OTHERS) | ⑦ 2\" VENT/CHECK VALVE |
| ③ 12\" CHECK VALVE | ⑧ AIR RELEASE VALVE (1\") |
| ④ 12\" PLUG VALVE | ⑨ PIPE SUPPORT ON PIER |
| ⑤ SIGMA 900 MAX SAMPLER | ⑩ PIPE SUPPORT ON WALL |

NOTES:

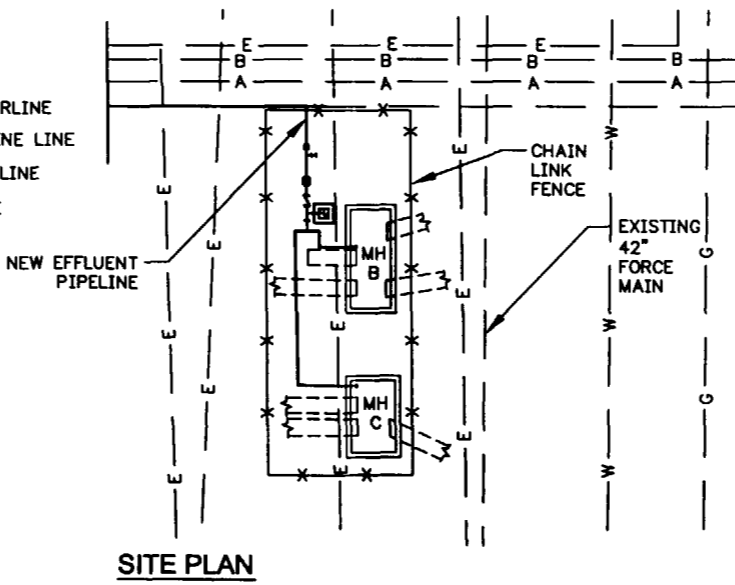
- 1) ADD TO EXISTING CHAIN LINK FENCE AROUND MANHOLES B AND C AS REQUIRED TO ACCOMMODATE THE NEW PIPING AND FITTINGS. MAINTAIN SOUTHEASTERN CORNER OF ENCLOSURE IN ITS CURRENT LOCATION, MOVE EXISTING DOUBLE GATE AS REQUIRED, AND EXTEND THE FENCE TO THE NORTH AND SOUTH AS APPROVED BY OWNER. ALL NEW FENCE SHALL MATCH THE EXISTING FENCE.
- 2) DESIGN, FURNISH, AND INSTALL INSULATION AND HEAT TRACING ON ABOVE GROUND PIPING UPSTREAM OF PLUG VALVES.
- 3) DESIGN, FURNISH AND INSTALL AREA LIGHTING WITH DUSK-TO-DAWN CELLS.
- 4) DESIGN AND INSTALL POWER SERVICE AND ELECTRICAL DISTRIBUTION FOR HEAT TRACING, INSTRUMENTS, AND AREA LIGHTING.
- 5) ANCHOR PIPE TO EXISTING MANHOLES USING 4, 3/4-IN. DIA. STAINLESS STEEL ANCHORS EMBEDDED 6 IN. WITH 3 IN. OF EXPOSED THREADS. CENTER SUPPORTS ON WALLS.

REFERENCE DRAWINGS:

MANHOLES C AND I, VILLAGE OF SAUGET, ILLINOIS SEWER REHABILITATION, SHEET 1, AS-BUILT 1/24/91, P.H. WEIS & ASSOCIATES INCORPORATED
T.R.R.A., VILLAGE OF SAUGET, ILLINOIS SEWER REHABILITATION, SHEET 1, AS-BUILT 1/24/91, P.H. WEIS & ASSOCIATES INCORPORATED

LEGEND

- | | |
|-----|---------------------------|
| —W— | EXISTING 16\" WATERLINE |
| —B— | EXISTING 6\" BENZENE LINE |
| —A— | EXISTING 6\" ACID LINE |
| —G— | EXISTING GAS LINE |



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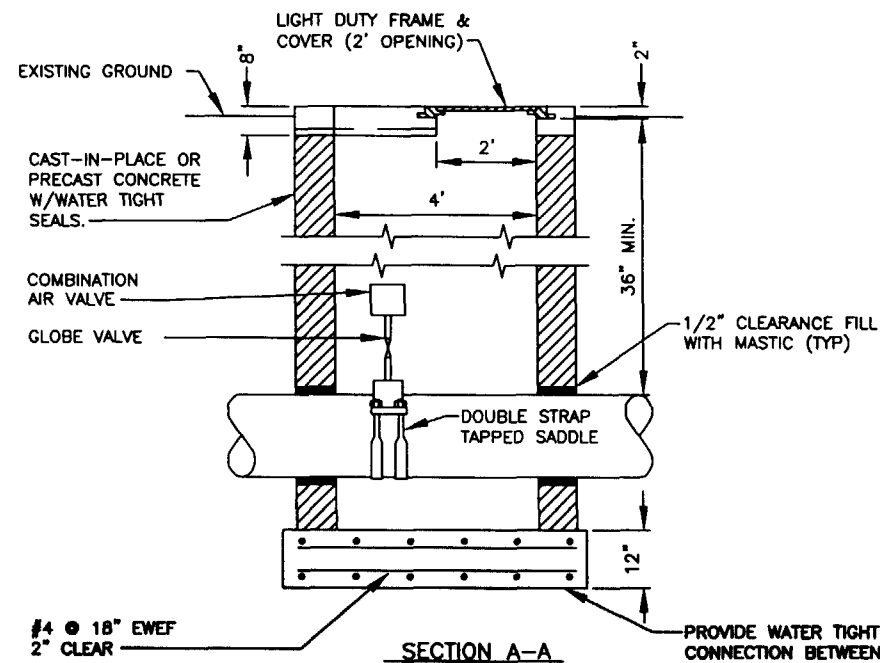
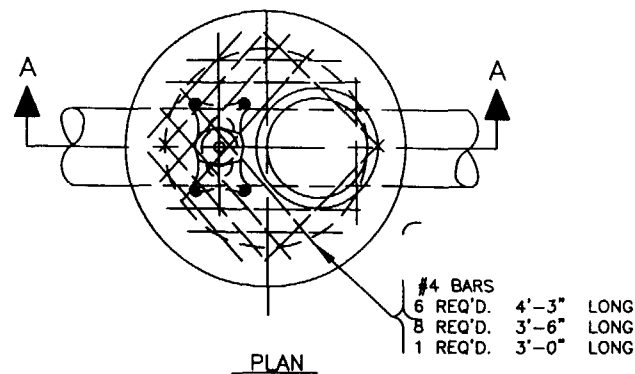
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Applied Chemistry. Creative Solutions

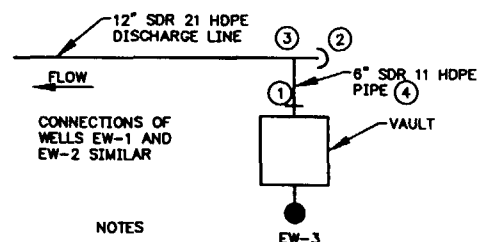
SOLUTIA INC.
575 MARYVILLE CENTRE DRIVE
ST. LOUIS, MO. 63141

GROUNDWATER MIGRATION CONTROL SYSTEM
EFFLUENT PIPELINE
PIPING PLAN & DETAILS AT DISCHARGE POINT

URS PROJECT NO.
21561192.00001
SHEET NO.
2-17

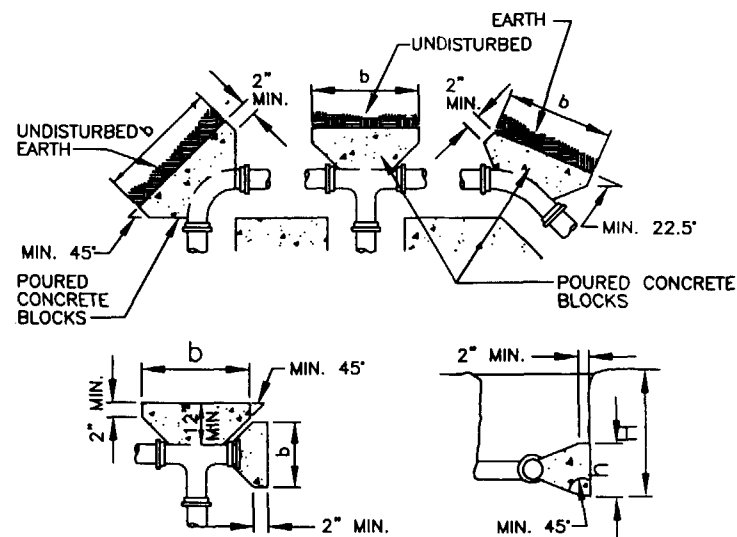


DETAIL B
VACUUM AND AIR RELIEF VALVE MANHOLE
NOT TO SCALE



- NOTES
- ① FLANGE OR OTHER APPROVED CONNECTION
 - ② MOLDED SDR 11 HDPE CAP
 - ③ 12"x6" SDR 11 HDPE BRANCH SADDLE
 - ④ BED HDPE PIPE IN SAND SIMILAR TO DETAIL C

DETAIL D
WELL-TO-DISCHARGE CONNECTION
NOT TO SCALE

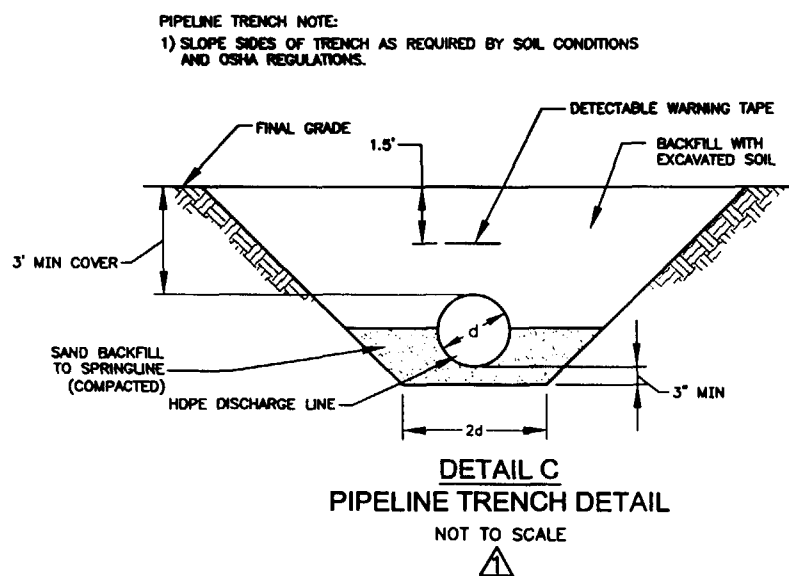
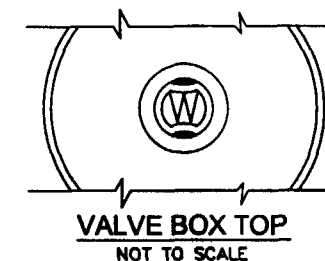


TYPICAL THRUST BLOCKING DETAILS
NOT TO SCALE

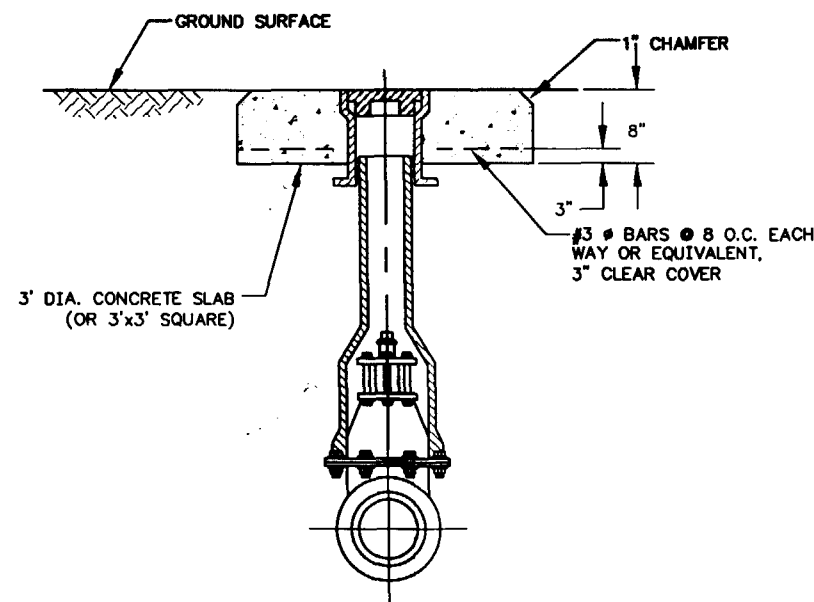
- THRUST BLOCKING NOTES:**
1. PLACE 4 MIL. POLYETHYLENE BETWEEN CONCRETE AND FITTING (CONCRETE SHALL NOT INTERFERE WITH JOINT.)
 2. MINIMUM CONCRETE THICKNESS SHALL BE 12 INCHES.
 3. THE HORIZONTAL DIMENSION (b) OF THE BEARING AREA SHALL BE BETWEEN 1.0 AND 2.0 TIMES THE VERTICAL DIMENSION (h). ($h \leq b \leq 2h$)
 4. THE VERTICAL DIMENSION (h) OF THE BEARING AREA SHALL BE EQUAL TO ONE-HALF THE TOTAL DEPTH (H) TO THE BOTTOM OF THE THRUST BLOCK BUT NOT LESS THAN THE OUTSIDE DIAMETER (D_o) OF THE FITTING ($D_o < h \leq H/2$).
 5. THRUST BLOCK ORIENTATION SHALL BE SUCH THAT THE CENTER OF THE FITTING CORRESPONDS WITH THE CENTER OF THE THRUST BLOCK.
 6. THE MINIMUM ALLOWABLE ANGLE (EITHER VERTICAL OR HORIZONTAL) SHALL BE 45 DEGREES.

BEARING AREA OF BLOCK IN SQ. FT. (b x h)					
FITTING SIZES	TEE & END	90° BEND	45° BEND	22 1/2° BEND	11 1/4° BEND
12"	4.0	4.0	4.0	2.0	2.0

(FIGURES TO BE ENTERED IN TABLE WHEN RANGE OF PIPE SIZES IS DETERMINED)



DETAIL C
PIPELINE TRENCH DETAIL
NOT TO SCALE



DETAIL OF VALVE BOX
NOT TO SCALE

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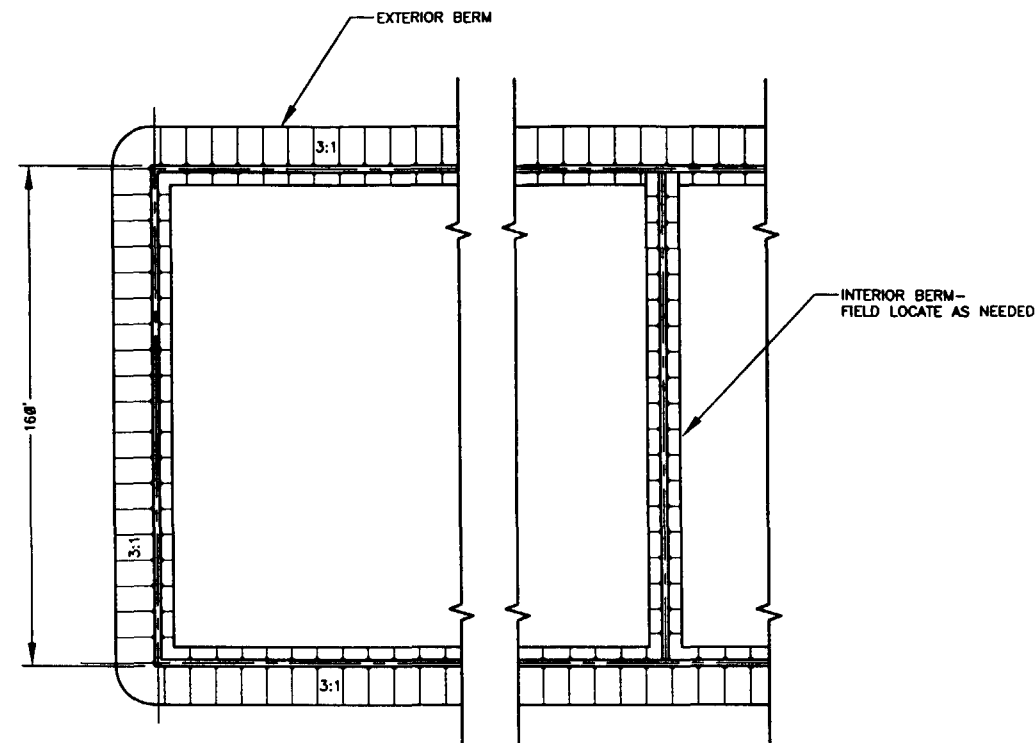
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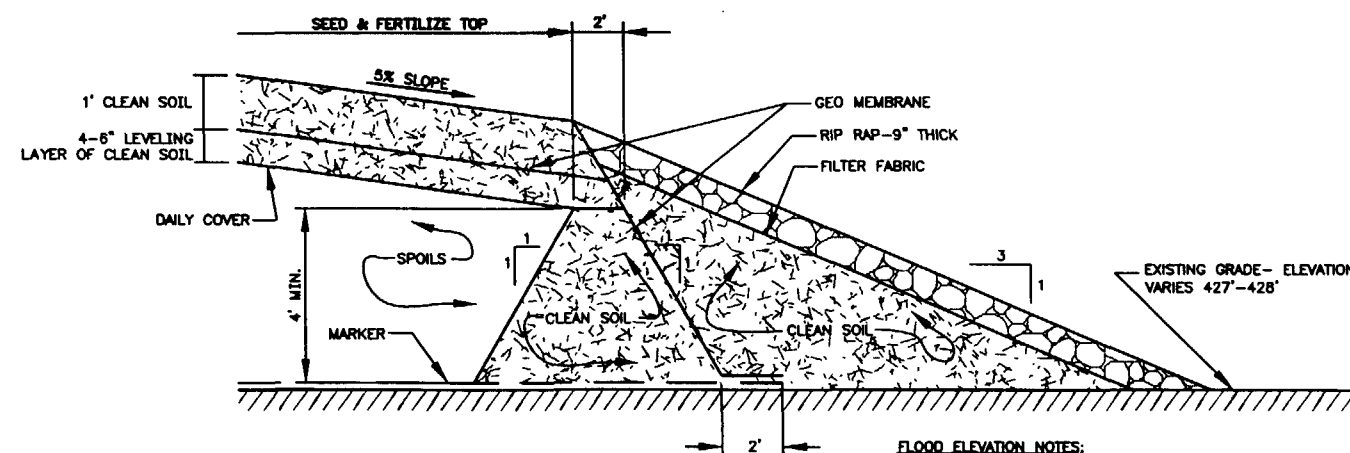


SOLUTIA INC.
575 MARYVILLE CENTRE DRIVE
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GROUNDWATER MIGRATION CONTROL SYSTEM		URS PROJECT NO.
EFFLUENT PIPELINE		21561192.00001
PIPING DETAILS		SHEET NO.
		2-18

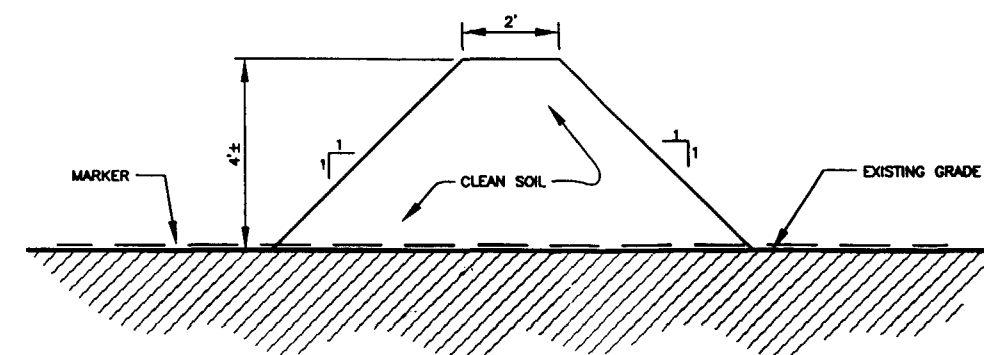


TEMPORARY STOCKPILE
N.T.S.



TYPICAL EXTERIOR BERM
N.T.S.

FLOOD ELEVATION NOTES:
-500 YR FLOOD - 428.8
-100 YR FLOOD - 427.0
-EXISTING LEVEE - 431.5



TYPICAL INTERIOR BERM
N.T.S.

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PREPARED BY:

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DATE: 7/3/03

SCALE: AS SHOWN

DESIGNED: MJB

DRAWN: DDP/VDL

CHECKED: MJB

SUBMITTED:



SOLUTIA INC.
575 MARYVILLE CENTRE DRIVE
ST. LOUIS, MO. 63141

GROUNDWATER MIGRATION CONTROL SYSTEM	URS PROJECT NO.
PACKAGE 2 - BARRIER WALL	21561192.00001
TEMPORARY STOCKPILE DETAILS	SHEET NO.

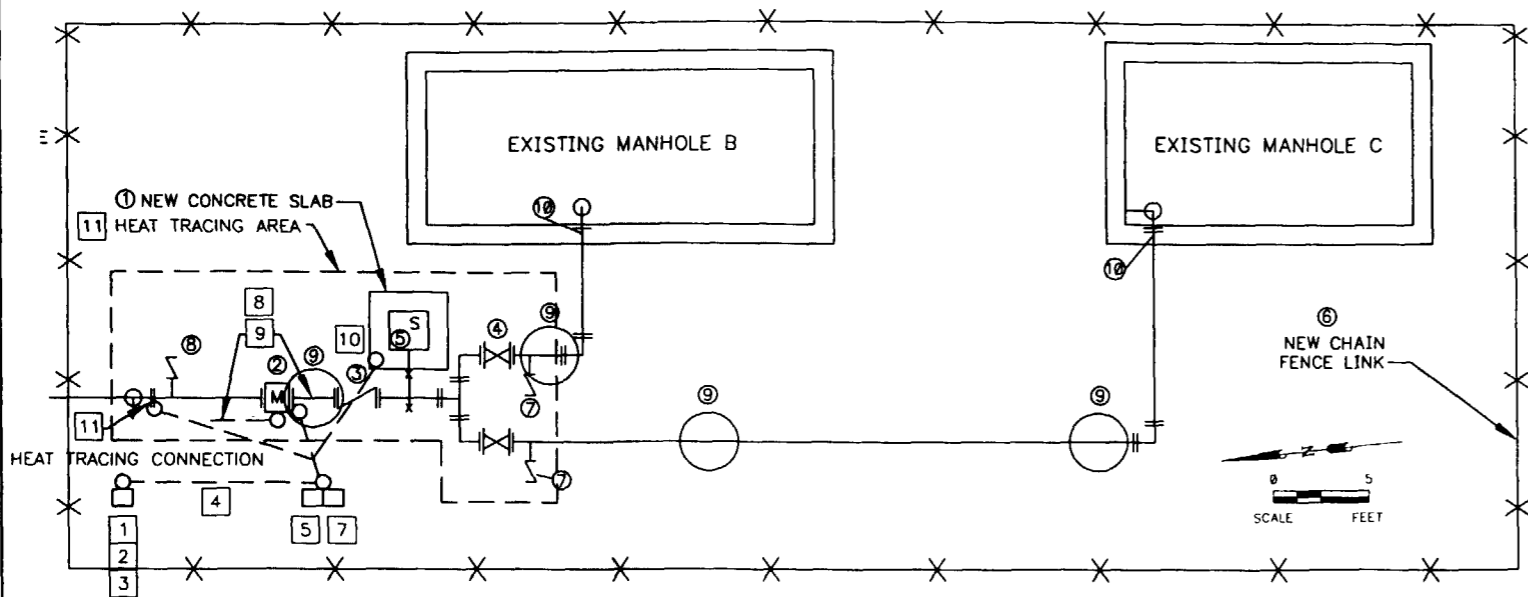
2-19

GENERAL NOTES:

- 1. MINIMUM CONDUIT SIZE SHALL BE 3/4 INCH.
- 2. MINIMUM POWER WIRING SIZE SHALL BE #10 AWG, TYPE THHN/THWN, STRANDED COPPER.
- 3. ALL CONDUIT SHALL BE GRC (GALVANIZED RIGID CONDUIT)
- 4. AN INSULATED COPPER GROUNDING CONDUCTOR SHALL BE INSTALLED AND CONNECTED WITH ALL CIRCUITS.

ELECTRICAL KEYED NOTES:

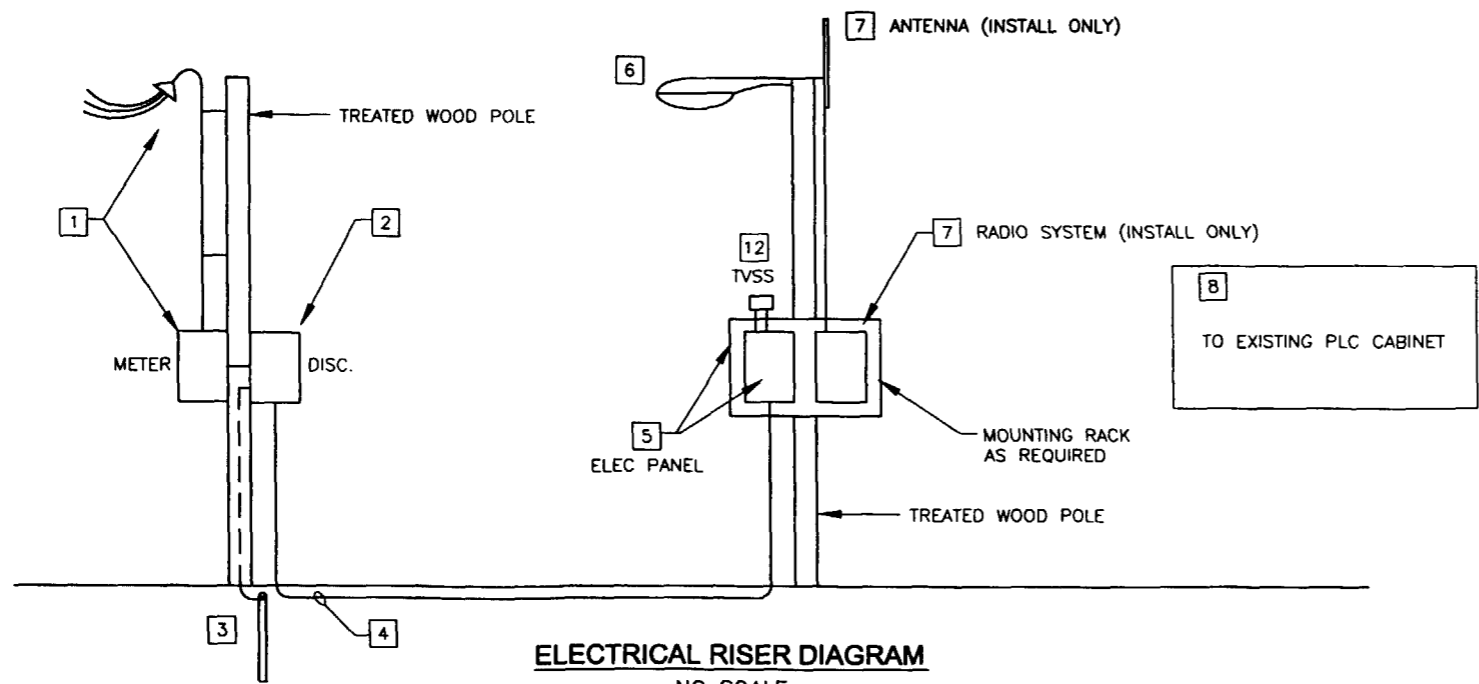
- 1 PROVIDE WOOD POLE WITH WEATHERHEAD, CONDUITS, METER BASE, AND WIRING REQUIRED BY UTILITY FOR NEW 120/240 VOLT, SINGLE PHASE SERVICE. PROVIDE SERVICE FROM ELECTRIC UTILITY COMPANY.
- 2 PROVIDE 2P-60/60A FUSED DISCONNECT SWITCH IN NEMA 3R ENCLOSURE AS SERVICE ENTRANCE EQUIPMENT.
- 3 PROVIDE 5/8" x 8' GROUND ROD WITH #8 GROUNDING ELECTRODE CONDUCTOR CONNECTED TO GROUND LUG OF DISCONNECT.
- 4 PROVIDE UNDERGROUND 1" GALVANIZED RIGID CONDUIT WITH 3 #6, 1 #8 GROUND FROM DISCONNECT SWITCH TO PANEL.
- 5 PROVIDE 120/240 VOLT, SINGLE PHASE, 60 AMP MAIN LUG PANEL IN NEMA 3R ENCLOSURE ON WOOD POLE (MINIMUM 26' LONG POLE WITH 20' ABOVE GRADE) WITH THE FOLLOWING BRANCH CIRCUIT DEVICES:
 - (1) 1P-20A RADIO TELEMETRY UNIT
 - (1) 1P-20A FLOW METER
 - (1) 1P-20A AREA LIGHT
 - (1) 1P-20A SAMPLER
 - (3) 1P-20A SPARES
 - (1) 1P-20A (30MA EQUIPMENT GROUND FAULT) HEAT TRACING.
 - AT LEAST (4) 1P-SPACE FOR FUTURE DEVICES.
- 6 PROVIDE AREA LIGHT NEAR TOP OF POLE (LITHONIA CHLD OR APPROVED EQUAL, 150 WATT HIGH PRESSURE SODIUM, 120 VOLT WITH INTEGRAL FUSING AND PHOTO CELL). CONNECT TO AREA LIGHT CIRCUIT IN PANEL.
- 7 NOT USED
- 8 EXISTING PLC AT P-CHEM PLANT. REFER TO DRAWING 2-15 FOR LOCATION AND CONDUIT REQUIREMENTS. CONNECT FLOWMETER ANALOG WIRING (NOTE 9) TO OWNER-FURNISHED 4-20 mA INPUT CARD.
- 9 INSTALL AND CONNECT MAGNETIC FLOWMETER (120 VOLT POWER SOURCE, 4-20MA ANALOG SIGNAL IN SEPARATE CONDUIT). PROVIDE ANALOG WIRING AND GROUND CONNECTION PER MANUFACTURER RECOMMENDATIONS.
- 10 MAKE POWER CONNECTIONS (HARD-WIRED) TO SAMPLER UNIT PER MANUFACTURER RECOMMENDATIONS.
- 11 ON PIPING SYSTEM IN AREA INDICATED, PROVIDE SELF-LIMITING HEAT TRACING EQUAL TO RAYCHEM TYPE BTV. FOLLOW MANUFACTURER RECOMMENDATIONS FOR CABLE INSTALLATION DESIGN AND WATT DENSITY. FOLLOW MANUFACTURER DETAILS FOR INSTALLATION ON PIPING, FITTINGS, VALVES, FLOWMETER, ETC. PROVIDE FIXED LINE THERMOSTAT TO ENERGIZE TRACING BELOW 40 DEGREES FAHRENHEIT. CONNECT TO EQUIPMENT GROUND FAULT CIRCUIT IN PANEL.
- 12 PROVIDE CATEGORY C, AT LEAST MEDIUM EXPOSURE, TRANSIENT VOLTAGE SURGE SUPPRESSOR (TVSS) AT LUGS OF PANELBOARD. CONNECT DISCHARGE TO GROUND BUS.



ELECTRICAL PLAN
AT DISCHARGE POINT
1"=1'

LEGEND

- 1 CONCRETE SLAB ON GRADE
- 2 12" MAGNETIC FLOW METER
- 3 12" CHECK VALVE
- 4 12" GATE OR PLUG VALVE
- 5 SIGMA 900 MAX SAMPLER
- 6 CHAIN LINK FENCE
- 7 2" VENT/CHECK VALVE
- 8 AIR RELEASE VALVE (1")
- 9 PIPE SUPPORT ON PIER
- 10 PIPE SUPPORT ON WALL



ELECTRICAL RISER DIAGRAM
NO SCALE

Ross & Baruzzini
6 SOUTH OLD ORCHARD
WEBSTER GROVES, MO. 63119
314-918-8383

NO.	DATE	REVISION DESCRIPTION	APPROVED

URS
1001 Highlands Plaza Dr. West, Suite 300
St. Louis, MO 63110

THE PROFESSIONAL WHOSE
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SEAL APPEAR HEREON
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OTHER DRAWINGS,
SPECIFICATIONS, ESTIMATES,
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NOT SEALED BY THE
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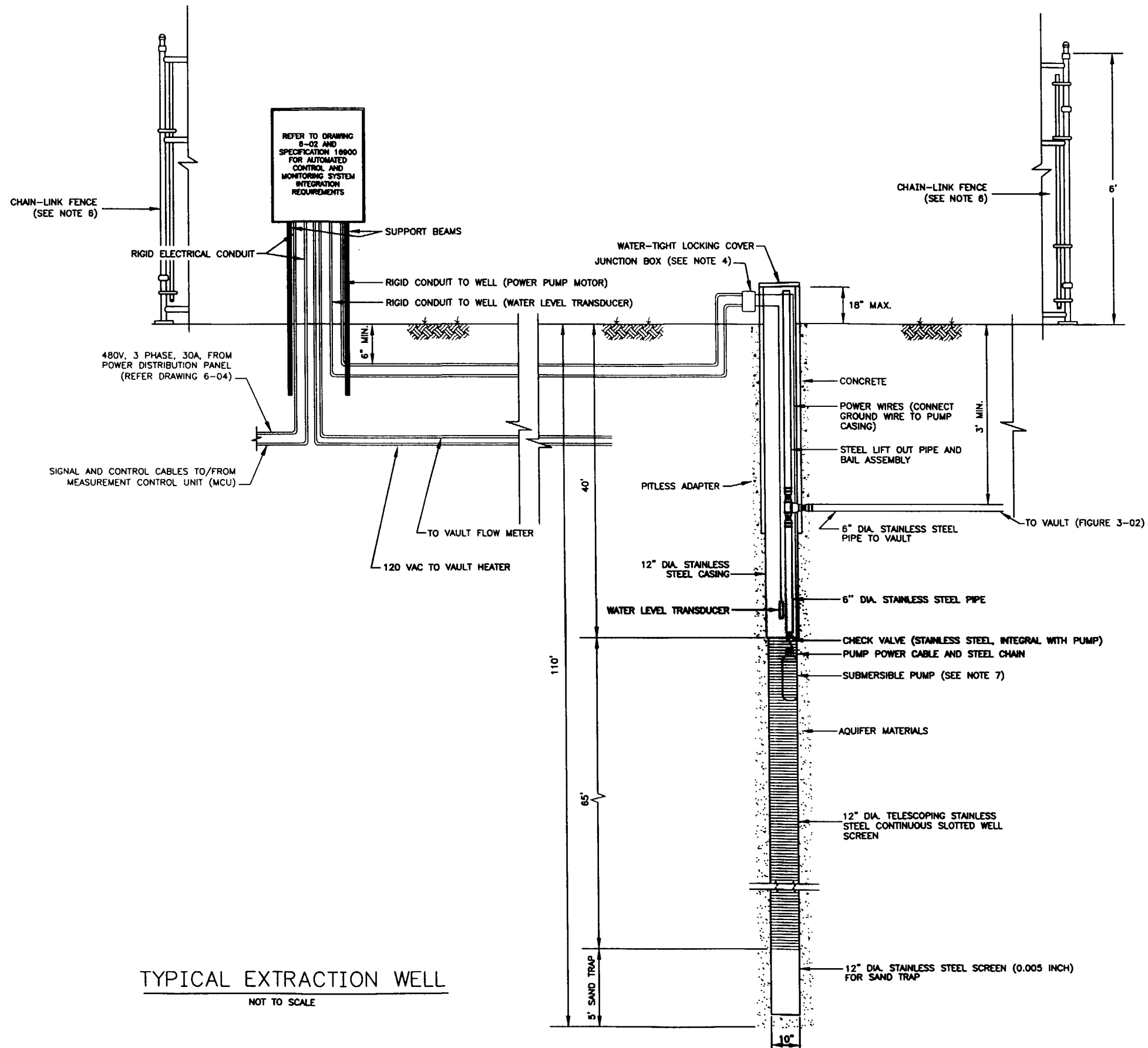
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DATE: 7/3/08
SCALE: AS SHOWN
DESIGNED: REV
DRAWN: TLA
CHECKED: RLF
SUBMITTED:



SOLUTIA INC.
575 MARYVILLE CENTRE DRIVE
ST. LOUIS, MO. 63141

GROUNDWATER MIGRATION CONTROL SYSTEM	URS PROJECT NO.
EFFLUENT PIPELINE	21561192.00001
ELECTRICAL PLAN & DETAILS AT DISCHARGE POINT	SHEET NO. 2-20



TYPICAL EXTRACTION WELL
NOT TO SCALE

NOTES

- 1.) TYPICAL WELL CONSTRUCTION. ACTUAL PLACEMENT OF WELL SCREEN AND CASING TO BE MODIFIED BY REMEDIAL DESIGNER BASED ON FIELD CONDITIONS.
- 2.) COMPLETION OF EXTRACTION WELLS SHALL BE UNDER THE DIRECT SUPERVISION OF THE REMEDIAL DESIGNER OR OTHER QUALIFIED PROFESSIONAL DESIGNATED BY SOLUTIA. THE FINAL COMPLETION OF EXTRACTION WELLS WILL BE BASED ON ACTUAL CONDITIONS ENCOUNTERED DURING WELL CONSTRUCTION.
- 3.) SUPPORT PUMP AND DISCHARGE PIPING FROM TOP. DO NOT ALLOW PITLESS ADAPTER TO SUPPORT PUMP UNLESS PITLESS ADAPTER IS CONCRETED IN PLACE. PROVIDE STAINLESS STEEL CHAIN TO ATTACH TO PUMP.
- 4.) ALL WIRING BETWEEN THE EXTRACTION WELLS AND CONTROL PANEL SHALL BE SUBMERSIBLE. CONNECT WIRES TO WELL CONDUIT USING SEAL TIGHT CONNECTORS. PROVIDE ELECTRICAL BOX (NEMA 6) AT GROUND SURFACE SIZED TO STORE A MINIMUM OF 5 FEET OF EXCESS WIRES (SLACK) COILED NEATLY IN JUNCTION BOX FOR ADJUSTING DEPTH IN WELLS.
- 5.) PRESSURE TRANSDUCER TO BE INSTALLED IN EACH WELL IN ORDER TO GAUGE DRAWDOWN, 5 FEET ABOVE TOP OF PUMP.
- 6.) CONTRACTOR SHALL INSTALL A CHAIN LINK FENCE ENCLOSURE AROUND THE PERIMETER OF EACH WELL.
- 7.) SUBMERSIBLE PUMP TO BE PLACED WITHIN SCREEN AT DEPTH OF 60 FEET BELOW GROUND SURFACE.
- 8.) EXISTING WELL EW-2 HAS 10.75-IN. O.D. CASING AND 10-IN. TELESCOPING WELL SCREEN.

FILE: E:\1181192\0001\TYPICAL EXTRACTION WELL 3-01.DWG Last edited: JUL 02 03 @ 5:48 p.m. by: D005040

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW



URS
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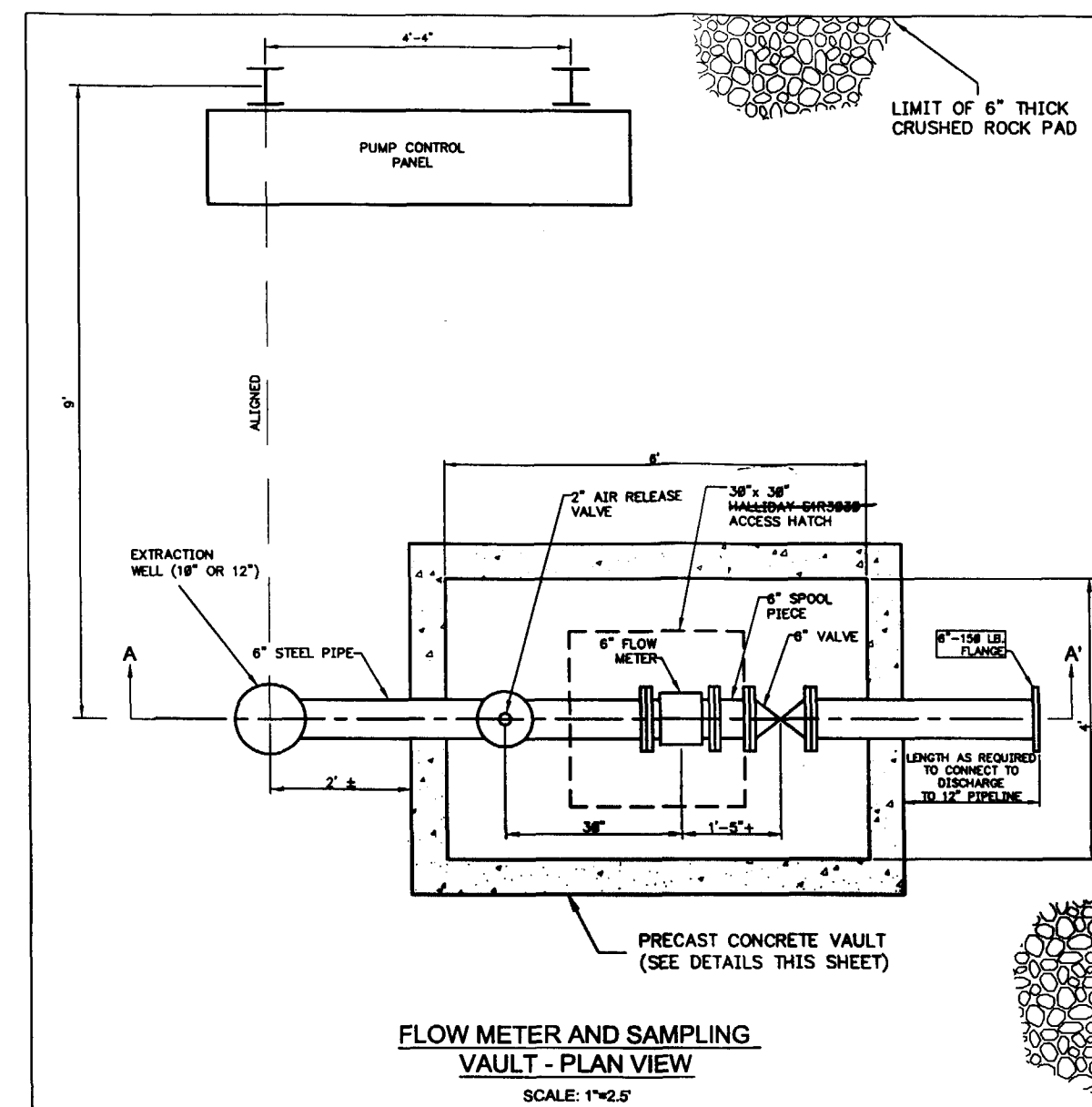
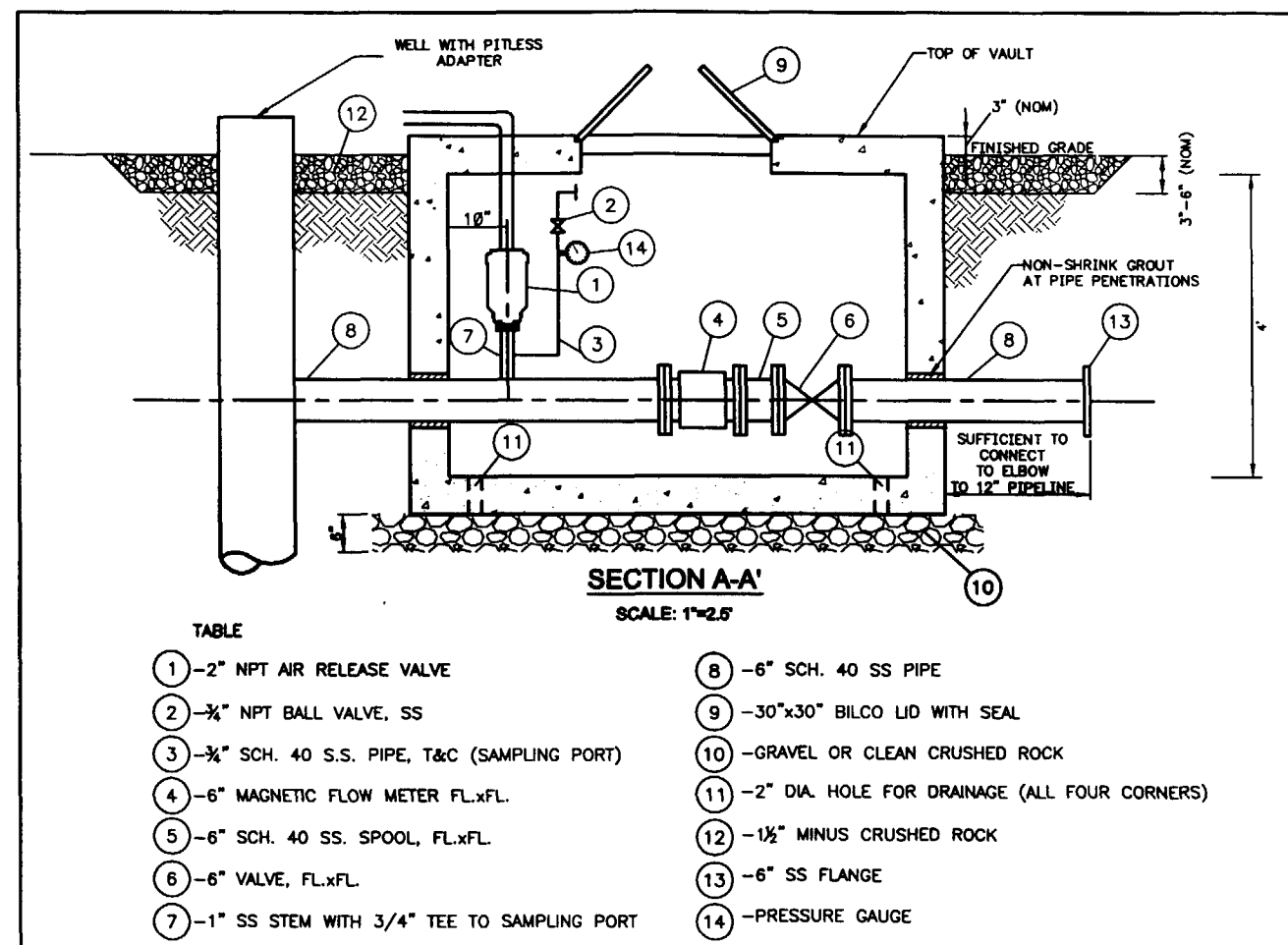
DATE:	7/3/03
SCALE:	AS SHOWN
DESIGNED:	JH
DRAWN:	MFM/DJD
CHECKED:	JH
SUBMITTED:	



SOLUTIA INC.
575 MARYVILLE CENTRE DRIVE
ST. LOUIS, MO. 63141

Applied Chemistry, Creative Solutions

GROUNDWATER MIGRATION CONTROL SYSTEM	URS PROJECT NO.
PACKAGE 2 - BARRIER WALL	21561192.00001
TYPICAL EXTRACTION WELL	SHEET NO.
	3-01



NOTES:

- 1.) HDPE GRADE PIPE GRADE SHALL BE USED OUTSIDE (DOWNSTREAM FROM) THE VAULT TO TRANSFER FLOW TO THE WASTEWATER DISCHARGE SYSTEM AT ITS DESIGN ELEVATION.
- 2.) CONTRACTOR SHALL INSTALL A GRAVEL PAD AND A CHAIN LINK FENCE ENCLOSURE AROUND THE PERIMETER OF EACH WELL. CONTRACTOR SHALL SUPPLY DUAL GATES WITH PADLOCKING LATCH FOR EACH ENCLOSURE AND POSITIONED TO ALLOW DIRECT ACCESS TO THE VAULT AND INTERNAL COMPONENTS. FINAL CHAIN LINK FENCE LAYOUT WILL ENCLOSE THE WELL, VAULT AND CONTROL PANEL STRUCTURES.
- 3.) ALL WIRING BETWEEN THE FLOW METER AND CONTROL PANEL SHALL BE IN CONDUIT INSTALLED BY DIRECT BURIAL.
- 4.) NORTH ARROW INDICATES PROJECT NORTH, THE DIRECTION OF PIPELINE FLOW.

06/06/03	MRS	ALIGNMENT, CONTROL PANEL AND PAD MODIFICATIONS	MSL	JRS	MRS
05/28/03	FMB	DIMENSION AND DETAIL REVISIONS	JAC	MRS	FMB
REV	DATE	REVISION DESCRIPTION	CADD	CHK	REV
PROJECT					
SOLUTIA, INC.					
SOLUTIA SITE R EXTRACTION WELLS					
Sauget, Illinois					
TITLE					
EXTRACTION WELL VAULT LAYOUT					
PROJECT No. 023-9806 FILE No. 0239806.001					
DESIGN	MRS	6/10/03	SCALE	AS SHOWN	REV. 0
CADD	JAC	6/10/03	3-02		
CHECK	JRS	6/10/03			
REVIEW					



NOTE:

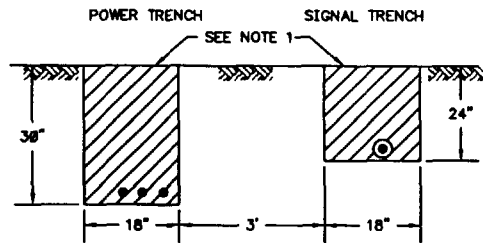
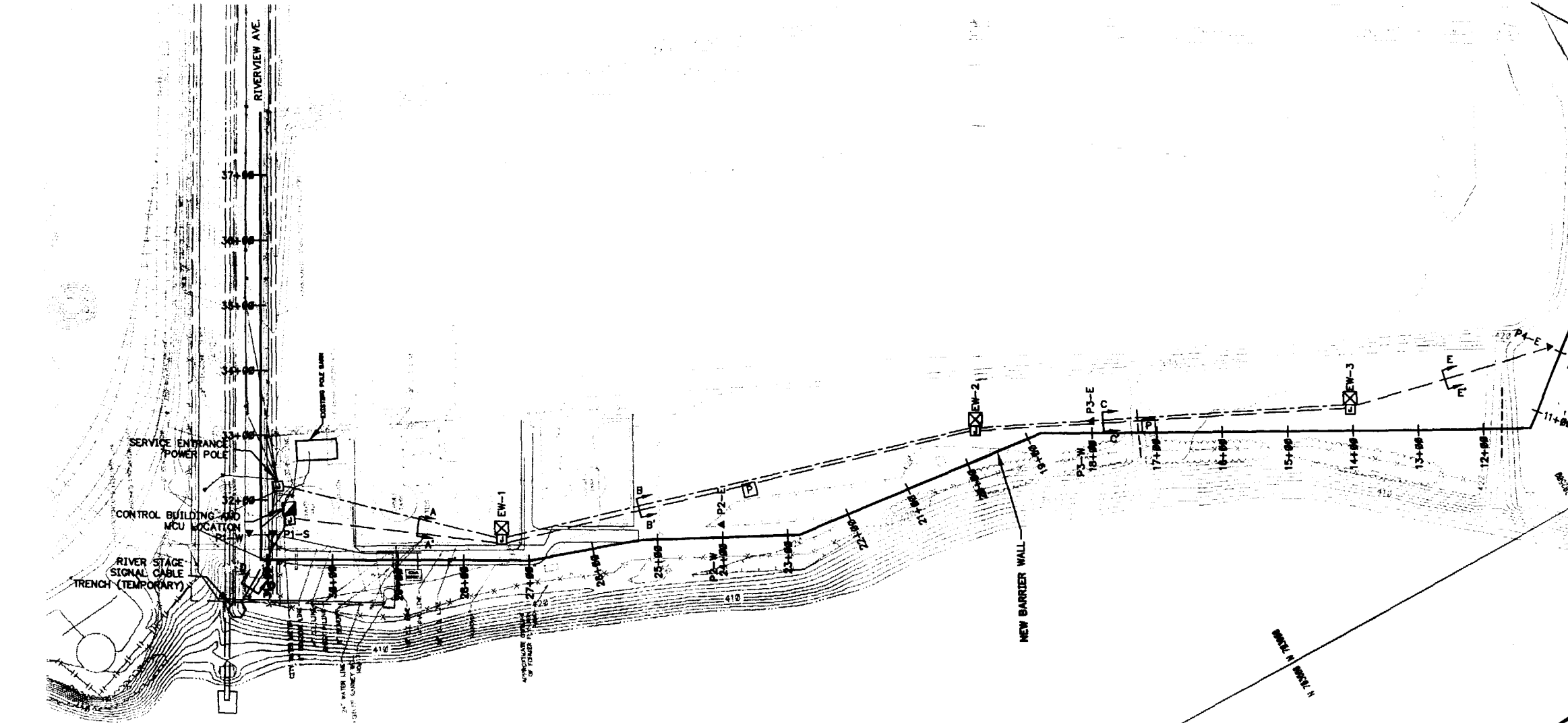
EXISTING SURFACE FEATURES HAVE BEEN PLOTTED FROM AN AERIAL SURVEY BY SURDEX. THE LOCATIONS OF UNDERGROUND UTILITIES, STRUCTURES AND FACILITIES HAVE BEEN PLOTTED FROM PLANS AND DRAWINGS OF EXISTING FACILITIES PROVIDED BY Solutia. THEIR LOCATIONS MUST BE CONSIDERED APPROXIMATE ONLY. THERE MAY BE OTHER IMPROVEMENTS AND UTILITIES WITHIN THE PROJECT AREA, WHICH ARE NOT SHOWN. THE CONTRACTOR SHALL VERIFY, PRIOR TO EXCAVATION OR CONSTRUCTION, THE LOCATIONS, ELEVATIONS AND DIMENSIONS OF ALL EXISTING UTILITIES, STRUCTURES, WELLS AND OTHER FEATURES AFFECTING HIS WORK, WHETHER OR NOT SHOWN ON THE PLANS. USE OF A SUBSURFACE LOCATOR IS RECOMMENDED.

SHOULD ANY FEATURE ADVERSELY AFFECT THE PROPOSED CONSTRUCTION, THE CONTRACTOR SHALL OBTAIN Solutia's APPROVAL FOR A CHANGE OR MODIFICATION TO THESE PLANS PRIOR TO PROCEEDING.

Legend

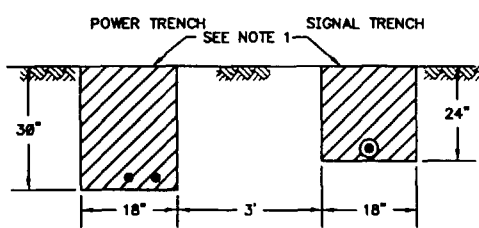
- EW - Extraction Well for GMCS
- P - Piezometer for GMCS
- J - JUNCTION BOX
- P - PULL BOX
- MCU - MEASUREMENT CONTROL UNIT (MCU)
- RS - RIVER STAGE GAUGE
- POWER CABLE/CONDUIT TRENCH
- SIGNAL CABLE/CONDUIT TRENCH
- RIVER STAGE CABLE/CONDUIT TRENCH

SCALE
0 100
FEET



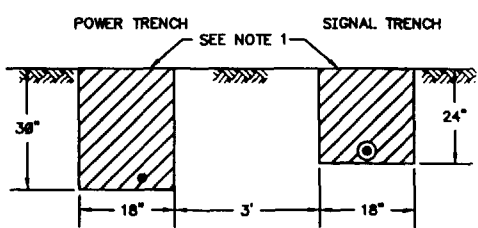
POWER: 3 - 3 EACH #1/8 cu (XH+HW), W/ #6 GR.(ANIXTER 3H1013)
SIGNAL: (1) 3" PVC ELECTRICAL CONDUIT
3 - 1 EACH (ANIXTER E-001222DFC)
3 - 1 EACH (ANIXTER E-000622DFC)

SECTION A-A'
NOT TO SCALE



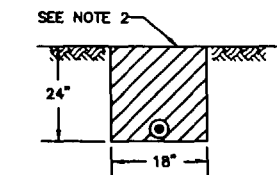
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SIGNAL: (1) 3" PVC ELECTRICAL CONDUIT
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3 - 1 EACH (ANIXTER E-000622DFC)

SECTION B-B'
NOT TO SCALE



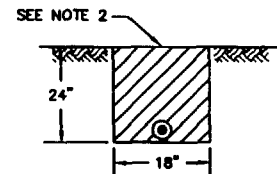
POWER: 1 - 3 EACH #1/8 cu (XH+HW), W/ #6 GR.(ANIXTER 3H1013)
SIGNAL: (1) 3" PVC ELECTRICAL CONDUIT
1 - 1 EACH (ANIXTER E-001222DFC)
1 - 1 EACH (ANIXTER E-000622DFC)

SECTION C-C'
NOT TO SCALE



SIGNAL: (1) 2" PVC ELECTRICAL CONDUIT
1 - 1 EACH (ANIXTER E-002522DFC)

SECTION D-D'
NOT TO SCALE



SIGNAL: (1) 2" PVC ELECTRICAL CONDUIT
1 - 1 EACH (ANIXTER E-000622DFC)

SECTION E-E'
NOT TO SCALE

TRENCH NOTES:

- BACKFILL POWER TRENCH AND SIGNAL CABLE TRENCH WITH COMPACT NATIVE BACKFILL FREE OF ROCKS AND DEBRIS. PLACE DETECTABLE WARNING TAPE AT DEPTH OF 12 INCHES.
- BACKFILL SIGNAL TRENCH WITH COMPACT NATIVE BACKFILL FREE OF ROCKS AND DEBRIS. PLACE DETECTABLE WARNING TAPE AT DEPTH OF 12 INCHES.

ELECTRICAL NOTES:

- SPLICES ARE NOT PERMITTED IN ANY FIELD SIGNAL CABLE.
- ALL JUNCTION BOXES AND PULL BOXES SHALL BE QUAZITE MODEL NO. PG2436BA24 W/ PG2436HA00 COVER.
- MAINTAIN CONTINUITY OF SHIELDS ACROSS ALL JUNCTION BOXES FOR SIGNAL CABLE.

PREPARED BY:

URS

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Tel: 314-429-0100
fax: 314-429-0462

DATE: 7/9/08

SCALE: AS SHOWN

DESIGNED: JH

DRAWN: DJD/VBL

CHECKED: JZ

SUBMITTED:



Solutia Inc.
575 Maryville Centre Drive
St. Louis, MO. 63141

Applied Chemistry, Creative Solutions

GROUNDWATER MIGRATION CONTROL SYSTEM

AUTOMATED CONTROL/MONITORING SYSTEM

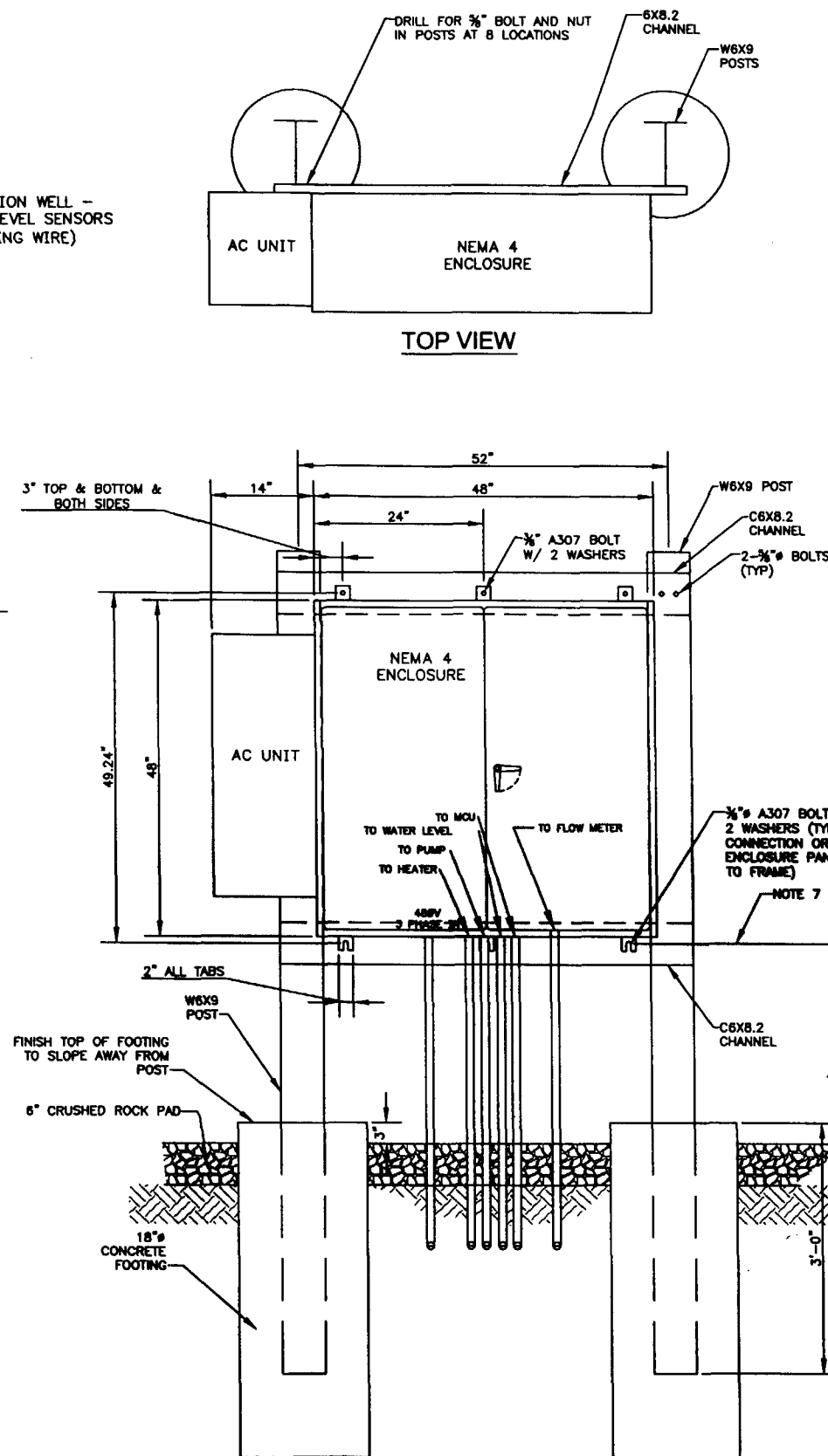
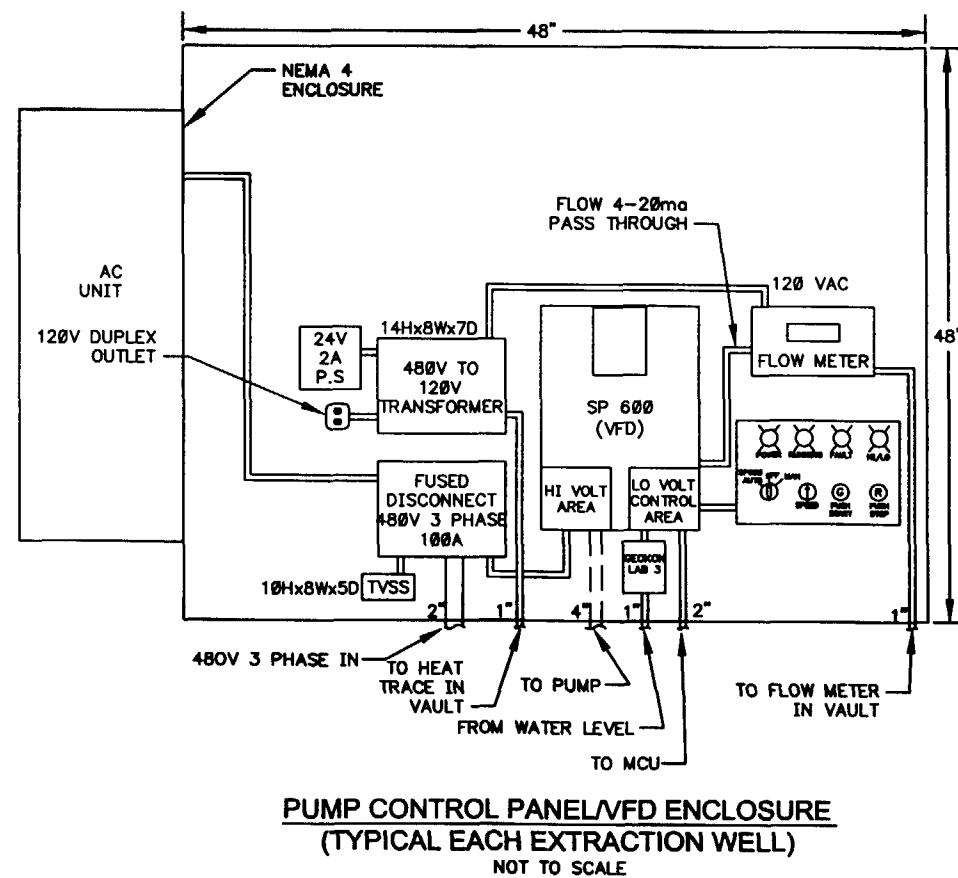
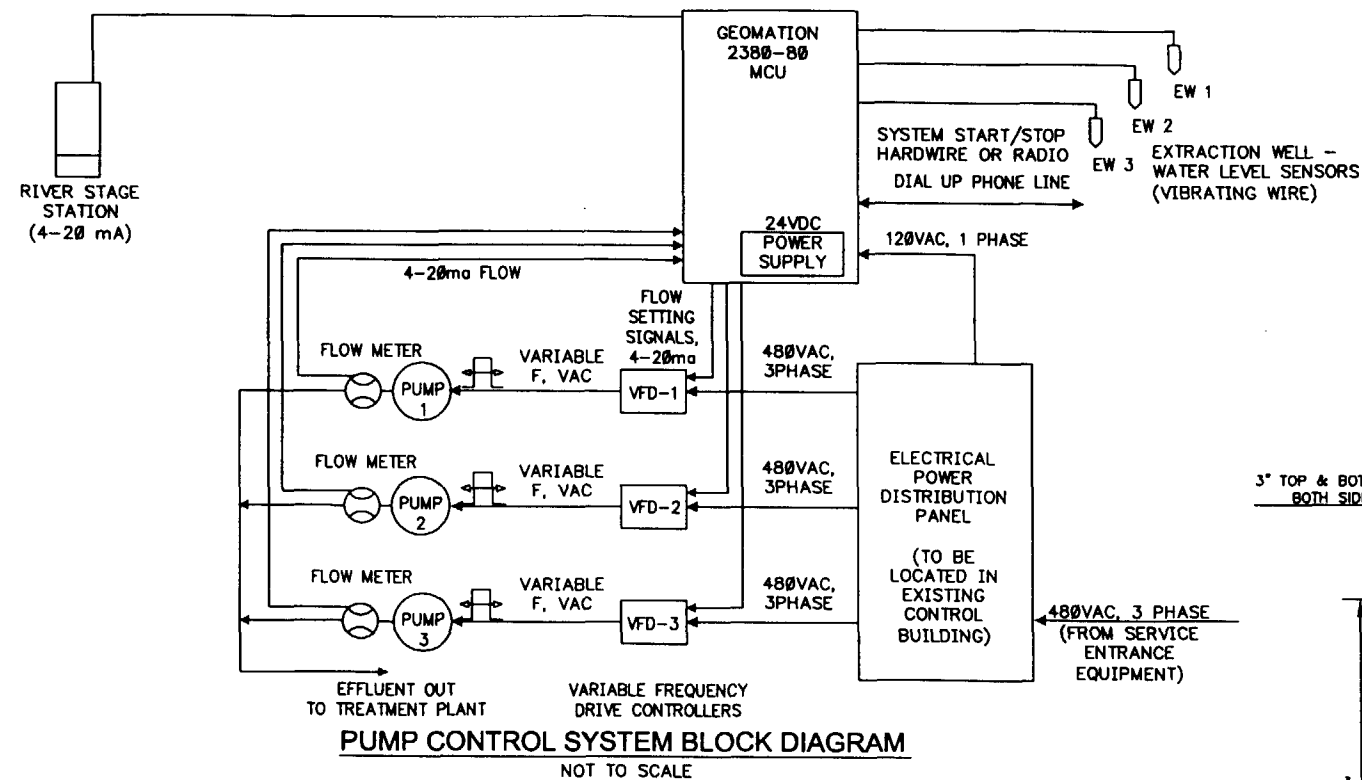
AUTOMATED CONTROL AND MONITORING
SYSTEM SITE PLAN

PROJECT NO.

21561238.00000

SHEET NO.

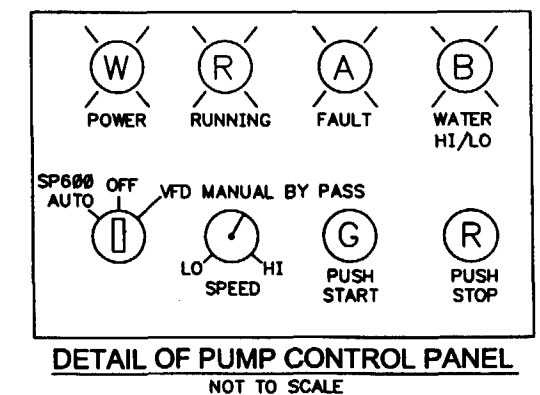
6-01



RIVER STAGE (FT, AMSL)	PUMPING RATE (GPM)	RIVER ELEVATION COMMENTS
430	0	HIGHEST RECORDED RIVER ELEVATION
413	0	
412	50	
411	100	
410	150	
409	200	
408	250	
407	300	
406	350	
405	400	
404	450	
403	500	
402	550	
401	600	HIGH MONTHLY AVERAGE FLOW
400	650	
399	700	
398	750	
397	800	
396	850	
395	900	
394	950	
393	1000	
392	1050	
391	1070	AVERAGE MONTHLY AVERAGE FLOW
390	1100	
389	1150	
388	1200	
387	1250	
386	1300	
385	1350	
384	1400	
383	1450	LOW MONTHLY AVERAGE FLOW
382	1500	
381	1550	
380	1600	
379	1650	
378	1700	
377	1750	
376	1800	
375	1850	
374	1900	LOWEST RECORDED RIVER ELEVATION

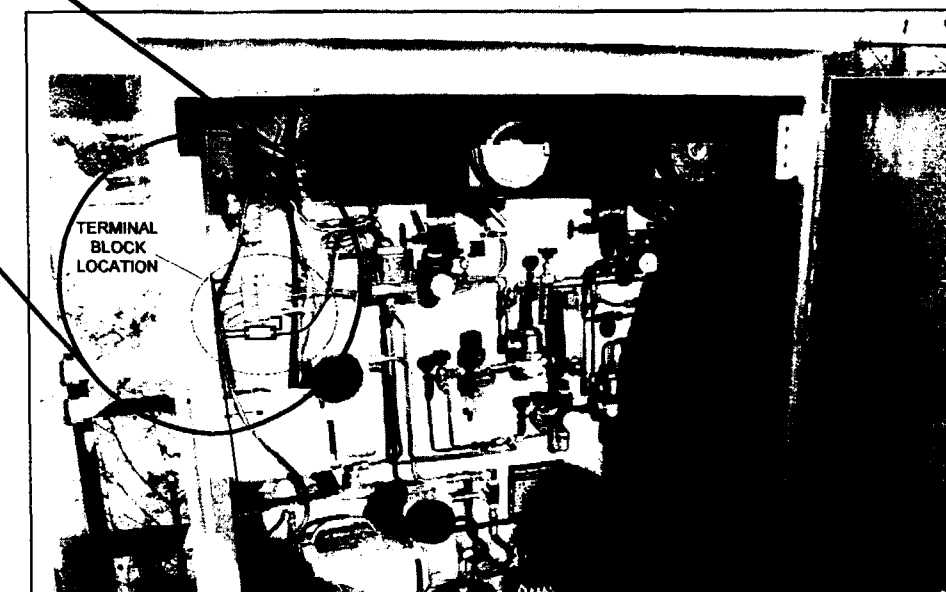
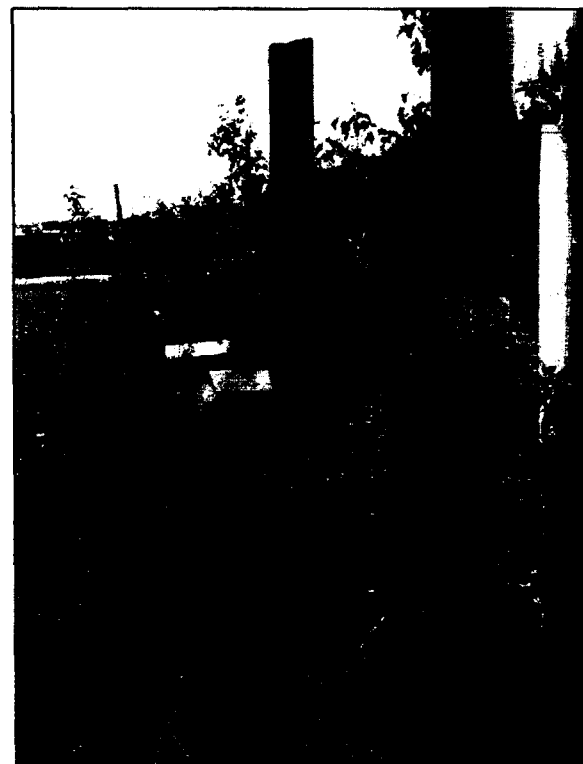
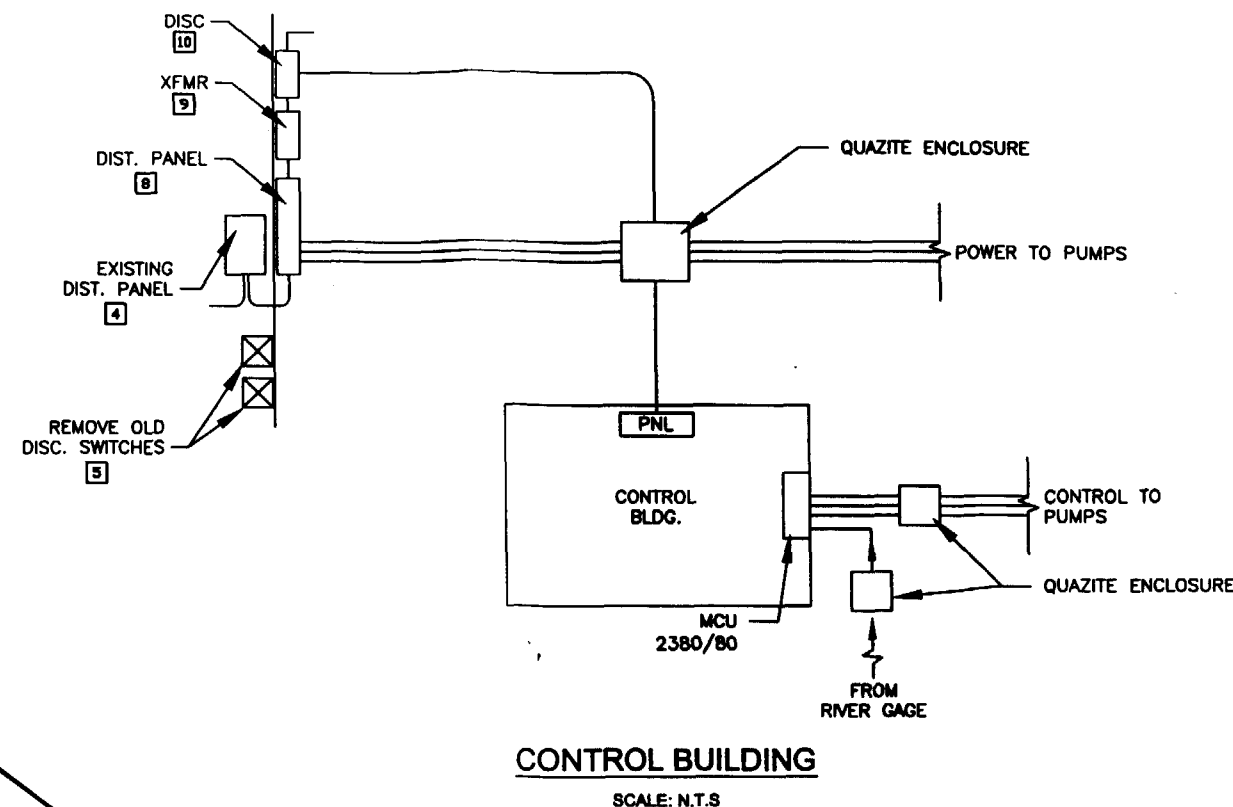
- NOTES:

- 1.) THE W6X9 POSTS & C6X8.2 CHANNEL SHALL BE GRADE 36 STEEL.
- 2.) ALL BOLTS SHALL BE A307. PROVIDE 2 WASHERS AND 1 NUT PER EACH BOLT.
- 3.) ALL STEEL SHAPES, BOLTS, WASHERS, & NUTS SHALL BE GALVANIZED IN ACCORDANCE WITH ASTM. POSTS AND CHANNELS SHALL BE GALVANIZED AFTER FABRICATION.
- 4.) REMOVE ALL GALVANIZING RUNS BEADS IN THE WASHER AREAS.
- 5.) THE NUT SHALL BE FREE RUNNING. IF THE NUT WILL NOT SPIN ON THE BOLT BECAUSE OF GALVANIZING IRREGULARITIES, A LUBRICANT SHALL BE APPLIED.
- 6.) FLANGE OF C6X8.2 CHANNEL SHALL BE COPED 4" MIN. BOTH ENDS.
- 7.) SET BOTTOM OF ENCLOSURE AT EL. 425.0 FEET NGVD.



KEYED NOTES:

- 1 EXISTING UTILITY COMPANY METER TO REMAIN.
- 2 EXISTING FUSED DISCONNECT SWITCH TO POLE BARN TO REMAIN.
- 3 EXISTING FEEDER TO POLE BARN TO REMAIN.
- 4 EXISTING 200 AMP FUSED DISCONNECT SWITCH TO REMAIN. REPLACE 2 EXISTING FUSES WITH 3 NEW TYPE FR5-R 200 AMP FUSES. USE TO SERVE NEW DISTRIBUTION PANEL (KEYED NOTE 8).
- 5 REMOVE EXISTING DISCONNECT SWITCHES, CONDUIT, AND WIRING SERVED FROM EXISTING DISCONNECT SWITCH (KEYED NOTE 4).
- 6 PROVIDE NEW TREATED PLYWOOD BACKBOARD IN THIS LOCATION ON BACK OF EXISTING SERVICE ENTRANCE BACKBOARD. SIZE SAME AS EXISTING. REMOVE EXISTING INACTIVE TRANSFORMERS, CONDUITS, AND CONDUCTORS AND CLEAN UP THE AREA AROUND BOTH SIDES OF THE BACKBOARD STRUCTURE.
- 7 RELOCATE EXISTING TELEPHONE PANEL ONTO NEW BACKBOARD.
- 8 PROVIDE NEW 480 VOLT PANEL, EQUAL TO SIEMENS SENTRON IN NEMA 3R LOCKABLE ENCLOSURE WITH 225 AMP OR 250 AMP MAIN LUGS, TVSS UNIT BOLTED TO THE MAIN BUS, AND BOLT-ON BRANCH CIRCUIT BREAKERS INDICATED IN SINGLE-LINE DIAGRAM, IN THIS LOCATION ON NEW BACKBOARD, TO SERVE NEW PUMPING SYSTEMS AND SINGLE PHASE TRANSFORMER.
- 9 PROVIDE NEW SINGLE PHASE TRANSFORMER (NEMA 3R ENCLOSURE) IN THIS LOCATION ON NEW BACKBOARD.
- 10 PROVIDE NEW NEMA 3R 2-POLE FUSED DISCONNECT SWITCH, IN THIS LOCATION ON NEW BACKBOARD, TO SERVE PANEL IN PORTABLE CONTROL BUILDING FROM SINGLE PHASE TRANSFORMER.



AMERICAN BOTTOMS RIVER GAGE SYSTEM
NOT TO SCALE

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NO.	DATE	REVISION DESCRIPTION	APPROVED

PREPARED BY:

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SEAL

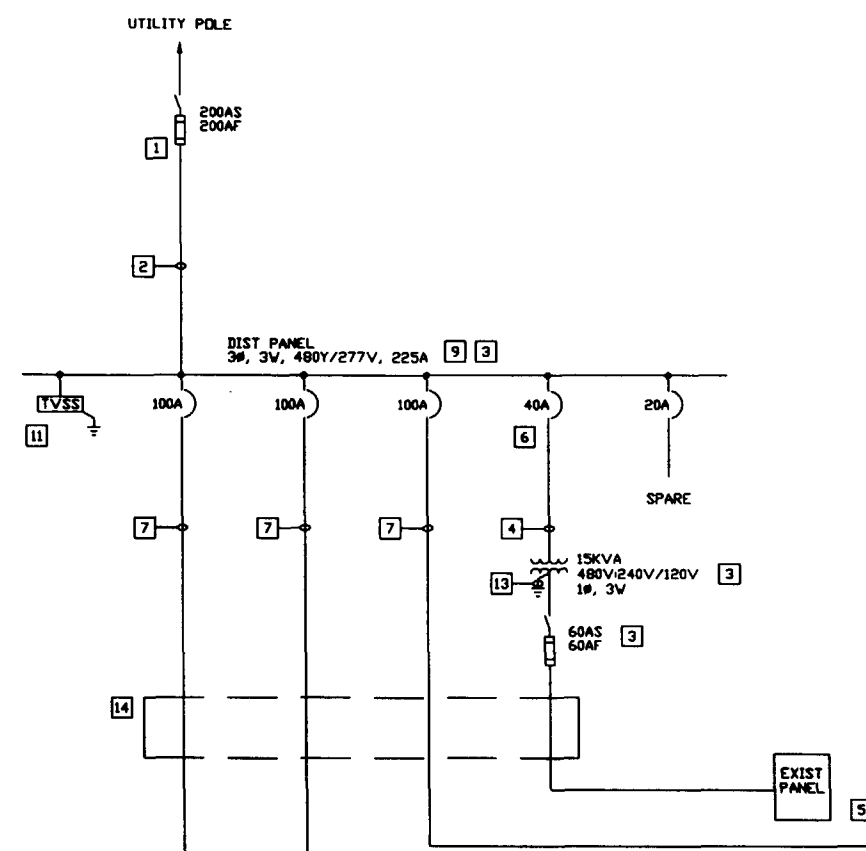
DATE: 7/3/03
SCALE: AS SHOWN
DESIGNED: JR
DRAWN: DJD
CHECKED: JR
SUBMITTED:

SOLUTIA
Applied Chemistry, Creative Solutions

SOLUTIA INC.
575 MARYVILLE CENTRE DRIVE
ST. LOUIS, MO. 63141

GROUNDWATER MIGRATION CONTROL SYSTEM
AUTOMATED CONTROL/MONITORING SYSTEM
POWER DISTRIBUTION PANELS AND RIVER
STAGE GAGE

URS PROJECT NO.
21561238.00000
SHEET NO.
6-05

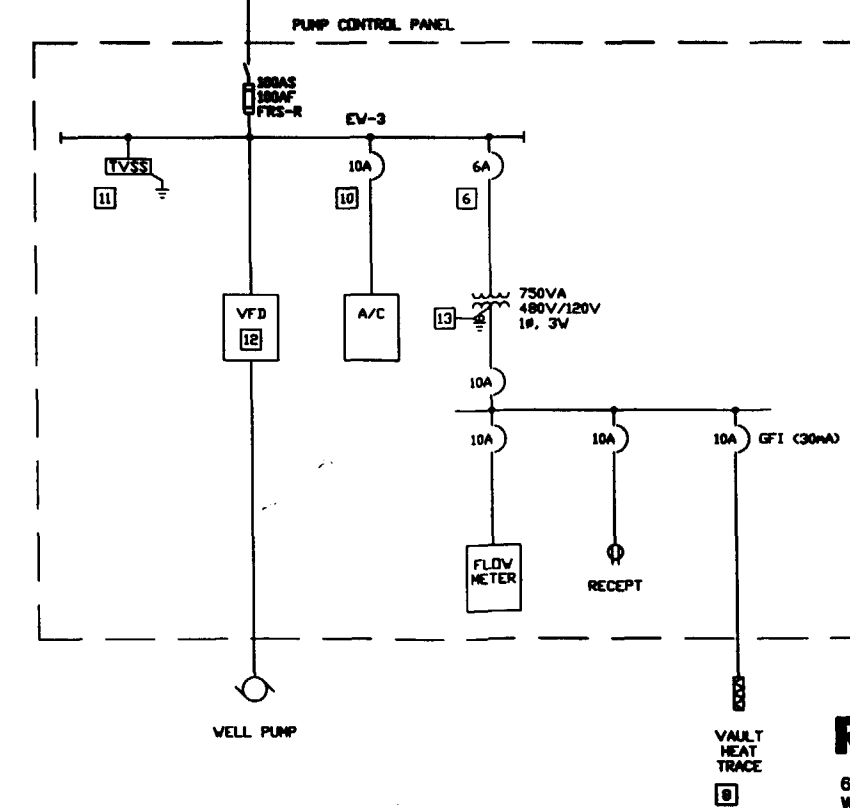
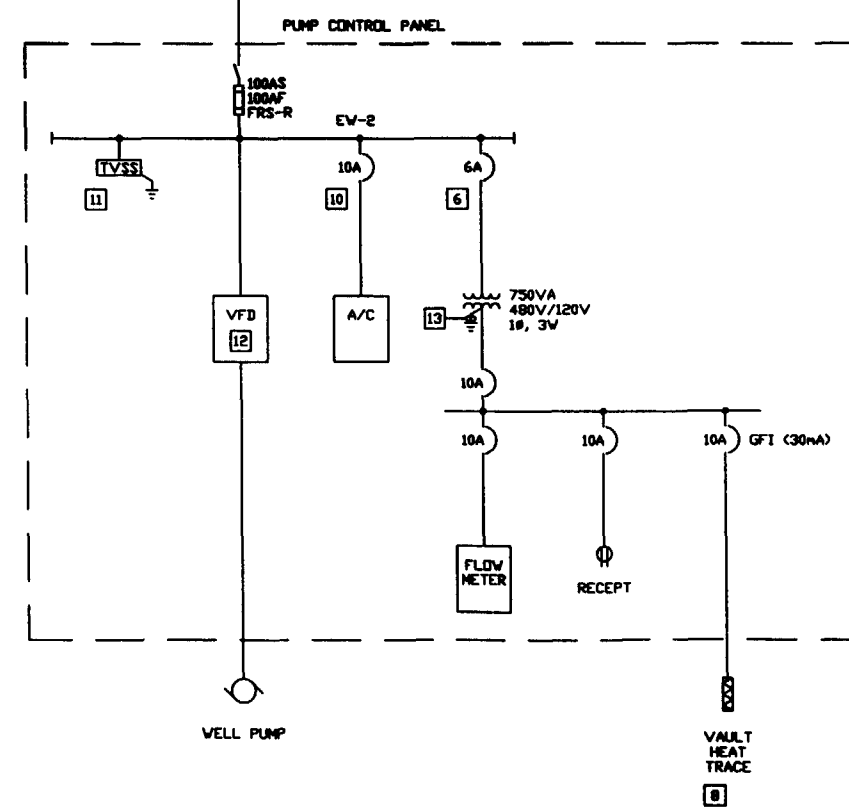
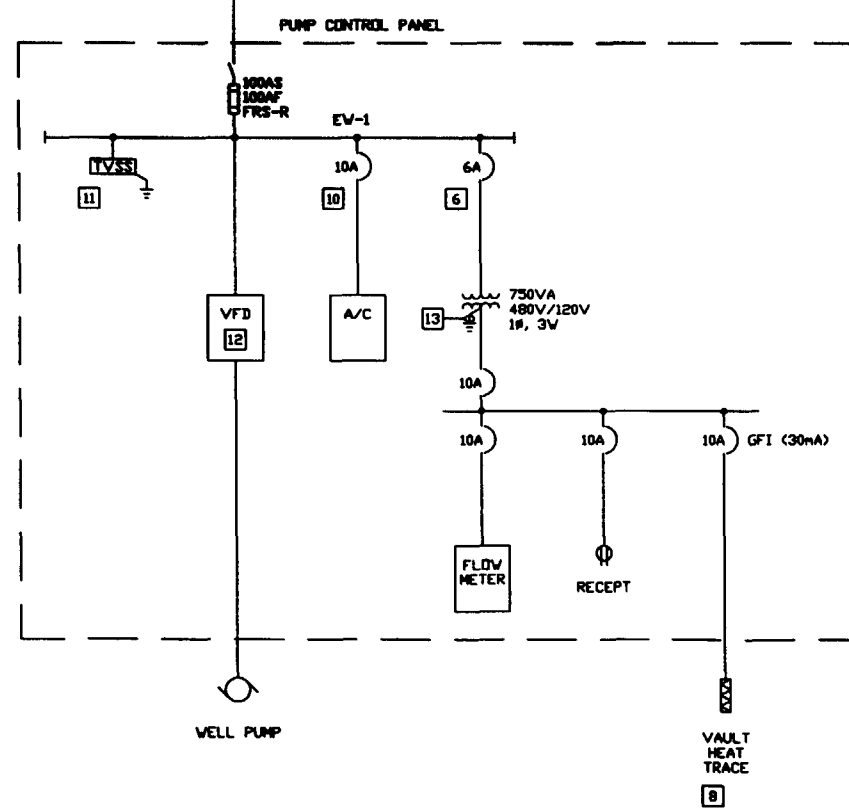


GENERAL NOTE:

DRAWING SHOWN IN LIGHT WEIGHT REPRESENTS EXISTING CONDITIONS. DRAWING SHOWN IN HEAVY WEIGHT REPRESENTS NEW WORK. EXISTING CONDITIONS ARE SHOWN FOR REFERENCE ONLY AND MAY NOT REPRESENT ALL CONDITIONS. CONTRACTOR SHALL FIELD VERIFY EXISTING CONDITIONS. CONTRACTOR SHALL NOT BE ALLOWED ADDITIONAL FUNDS DUE TO CONTRACTOR'S FAILURE TO BECOME FAMILIAR WITH EXISTING CONDITIONS.

ELECTRICAL KEYED NOTES:

- 1 EXISTING FUSED DISCONNECT SWITCH MOUNTED NEAR UTILITY POLE.
- 2 (3) #4/0 PHASE, (1) #4 GROUNDED SERVICE NEUTRAL CONDUCTOR.
- 3 PROVIDE NEMA 3R EQUIPMENT ON EXISTING ELECTRICAL SERVICE BACKBOARD NEAR UTILITY POLE.
- 4 (2) #8 PHASE, (1) #10 GROUND.
- 5 EXISTING PANELBOARD IN PORTABLE CONTROLS BUILDING. PROVIDE UNDERGROUND 1" CONDUIT WITH (3) #8, (1) #8 GROUND CABLE FROM TRANSFORMER TO DISCONNECT SWITCH TO BUILDING (THROUGH UNDERGROUND PULLBOX.) EXTEND GRC CONDUIT UP THE OUTSIDE OF BUILDING, STUB INTO BUILDING AT PANEL, AND MAKE CONNECTIONS.
- 6 480V SINGLE PHASE BREAKER.
- 7 (3) #1/0 PHASE, (1) #4 GROUND.
- 8 DESIGN, FURNISH, AND INSTALL HEAT TRACE SYSTEM WITH SELF-LIMITING CABLE ON EXPOSED PIPING AND FLOW METER IN FLOW METER VAULT. INSTALL PER MANUFACTURER'S RECOMMENDATIONS AND CONNECT TO A 30mA GROUND FAULT CIRCUIT BREAKER. HEAT TRACE CABLE SHALL BE RAYCHEM TYPE 8TV OR EQUIVALENT.
- 9 DISTRIBUTION PANEL SHALL HAVE RATINGS AS SHOWN WITH MAIN LUGS ONLY. PROVIDE MINIMUM NUMBER AND SIZE OF BRANCH CIRCUIT BREAKERS SHOWN. COORDINATE INTERRUPTING RATING WITH AVAILABLE FAULT CURRENT FROM UTILITY. PANEL SHALL BE SIEMENS SENTRON TYPE S2 OR EQUIVALENT.
- 10 480V THREE PHASE BREAKER.
- 11 TVSS, WITH ALL NECESSARY OVERCURRENT PROTECTION, SHALL BE RATED AND TESTED TO UL 1449 AND ANSI C82. RATING SHALL BE CATEGORY B, MEDIUM EXPOSURE. UNIT SHALL BE MOUNTED WITHIN PANEL AND CONNECTED WITH A MINIMUM #6 COPPER CONDUCTOR.
- 12 WITH INTEGRAL DISCONNECT AND OVERCURRENT PROTECTION.
- 13 GROUND PER NEC.
- 14 UNDERGROUND PULLBOX.



Ross & Baruzzini
6 SOUTH OLD ORCHARD
WEBSTER GROVES, MO. 63119
314-918-8383

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NO.	DATE	REVISION DESCRIPTION	APPROVED

PREPARED BY:
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1001 Highlands Plaza Dr. West, Suite 300
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Tel: 314-429-0100
fax: 314-429-0462

DATE: 7/3/03
SCALE: NONE
DESIGNED: HLB
DRAWN: HLB
CHECKED: NEW
SUBMITTED:

SOLUTIA
Applied Chemistry, Creative Solutions
SOLUTIA INC.
575 MARYVILLE CENTRE DRIVE
ST. LOUIS, MO. 63141

GROUNDWATER MIGRATION CONTROL SYSTEM	URS PROJECT NO.
AUTOMATED CONTROL/MONITORING SYSTEM	21561192.00001
ELECTRICAL POWER DIAGRAM	SHEET NO.
	6-06

Specifications

Section No.	Title
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Division 1 – General Requirements

01010	Summary of Work
01500	Mobilization & Temporary Facilities
01550	Site Preparation
01700	Demobilization & Project Closeout

Division 2 – Site Work

02100	Erosion and Stormwater Control During Construction
02150	Clearing and Grubbing
02190	Temporary Haul Roads
02290	Soil-Bentonite Barrier Wall
02300	Cement Soil Mixing (CDSM) Wall
02320	Construction Spoils Handling
02325	Geomembrane
02525	Extraction Wells
02526	Submersible Well Pump and Motor
02550	Effluent Pipeline and Appurtenances
02900	Site Restoration
02920	Chain Link Fences and Gates

Division 3 – Concrete

03300	Cast-in-Place Concrete
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Division 13 – Special Construction

13500	Piezometers
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Division 16 – Electrical

16500	Basic Electrical Power Materials and Methods
16900	Controls and Instrumentation

SECTION 01010

SUMMARY OF WORK

PART 1 - GENERAL

1.0 SECTION INCLUDES

- A. Background Information
- B. General Requirements
- C. Summary of Work

1.1 BACKGROUND INFORMATION

- A. Solutia Inc. (Owner) plans to construct a Groundwater Mitigation Control System (GMCS) at their property in Sauget, Illinois. The purpose of the GMCS is to mitigate or abate the discharge of environmentally impacted groundwater to the Mississippi River. The project consists of installation of 3 wells and well pumps, discharge piping and appurtenances and a 3,300 feet long barrier wall. The wall consists of two 650 feet long sections at the north and south ends and a 2,000 feet long section running parallel to the Mississippi River. Bedrock depth is about 120 to 140 feet below the existing ground surface. The barrier wall will extend from approximately 30 feet below ground surface to the top of the bedrock.
- B. The site is designated as Solutia Area 2-Site R. Subsurface information and geotechnical data are presented on the drawings. Access to the work site is by paved roads. A locked gate controls entry to the site.

1.2 GENERAL REQUIREMENTS

- A. Authority of Construction Manager
 - 1. The work will be reviewed, observed and inspected by the on-site Construction Manager in accordance with the contract, Plans, Specifications and the Construction Quality Assurance Manual for the GMCS. The Construction Manager will decide all questions which may arise as to the quality or acceptability of materials furnished and work performed, the manner of performance and rate of progress of the work, the interpretations of the Drawings and Specifications and the acceptable fulfillment of the contract on the part of the Contractor. Construction Manager's decisions will be final and binding.

B. Conformity with Drawings and Specifications

1. All work performed **and all materials** furnished shall be in conformity with the lines, grades, **cross sections**, dimensions, details, gradations, physical, and chemical **characteristics** of materials in accordance with tolerances shown on the **Drawings** and as required by the Specifications. Construction **tolerances** and accuracy limits will be as defined in the respective items of the contract or if not defined, as determined by the Construction Manager.
2. It is the responsibility of the Contractor to verify all quantities of materials shown on the **Drawings** before ordering same. The Contractor will not be paid for material rejected due to improper processing, excess quantity or for any other reasons **within his control**.
3. In the event the Construction Manager finds that the work performed or the materials used are not within conformity with the Drawings and Specifications, the affected material or product shall be removed and replaced or otherwise **satisfactorily** corrected by and at the expense of the Contractor.
4. Any deviations from the Plans, Specifications and approved Shop Drawings will be made **only** with the approval of the Construction Manager with the concurrence of the Designer. All requests for variance or modification shall be by written communication from the Contractor to the Construction Manager.
5. The Specifications accompanying the Drawings are essential parts of the contract and a requirement occurring in one is as binding as though occurring in all. They are **intended** to be cooperative and to describe and provide for a complete work. In cases of disagreement, dimensions provided on figures shall **govern** over scaled dimensions, Drawings shall govern over Specifications, **and Instructions** to Bidders. Addenda shall govern over all.

C. Cooperation of Contractor

1. The Contractor shall **designate**, to the Construction Manager in writing, the name of a Superintendent, **employed** by the firm, regardless of how much of the work may be sublet. The Superintendent shall be cooperative, responsible and competent, **English speaking**, authorized to receive orders and to act for the Contractor. The Superintendent will be on-site and

available at all times during site preparation, construction of the vertical barrier wall and all appurtenant work. In the event a competent superintendent is not available, the Construction Manager may suspend work at no additional cost to the Owner until one is available.

D. Removal of Defective and Unauthorized Work

1. All work which has been rejected as being in nonconformance with the Drawings and Specifications shall be remedied or removed and replaced in an acceptable manner by the Contractor at his expense. Work done without written authority will be considered as unauthorized and done at the expense of the Contractor and will not be paid for. Work so done may be ordered removed at the Contractor's expense. Upon failure on the part of the Contractor to comply with any order of the Construction Manager made under the provisions of this paragraph, the Construction Manager will have authority to cause defective work to be remedied or removed and replaced and unauthorized work to be removed and the cost thereof may be deducted from any moneys due or to become due to the contractor.

E. Protection of Adjoining Property

1. The Contractor shall take proper measures to protect the adjacent or adjoining property which might be injured by any process of construction, and, in case of any injury or damage resulting from any act or omission on the part of or on behalf of the Contractor, he shall restore at his own expense the damaged property to a condition similar or equal to that existing before such injury or damage was done, or he shall make good such injury or damage in an acceptable manner.

F. Contractor's Responsibility for Work

1. Until final written acceptance of the project by the Construction Manager, the Contractor shall have the charge and care thereof and shall take every precaution against injury or damage to any part thereof by the action of the elements or from any other cause, whether arising from the execution or from the nonexecution of the work. The Contractor shall rebuild, repair, restore, and make good all injuries or damages to any portion of the work occasioned by any of the above causes before final acceptance and shall bear the expense thereof which are a portion of the work, not damaged by the Contractor or his operations, except for damage to the work due to Acts of God (force majeure) such as earthquake, flood, tornado, or other cataclysmic phenomena of nature or acts of governmental authorities. In case of suspension of work for any cause, the Contractor shall be

responsible for the preservation of all materials. He shall provide suitable drainage and shall erect temporary structures where required.

G. Work Near Electrical Power Lines

1. Any operations by the Contractor that are located near any electrical power lines shall be accomplished using established industry and utility safety practices. The Contractor shall consult with the appropriate utility company prior to beginning any such work. All consultation and compliance will be the responsibility of the Contractor.

H. Workers and Equipment

1. The Contractor shall furnish such suitable machinery, equipment, and construction forces as may be necessary, in the opinion of the Construction Manager, for the proper prosecution of the work. Construction Manager may require the Contractor to provide additional resources to maintain the project schedule. Construction Manager may suspend the work until his requests are complied with.
2. All workers employed by the Contractor shall have such skill and experience as will enable them to properly perform the duties assigned. Any person employed by the Contractor or a subcontractor who, in the opinion of the Construction Manager, does not perform his work in a proper and skillful manner, or who is disrespectful, intemperate, disorderly or otherwise objectionable, shall at a written request of the Construction Manager be forthwith discharged and shall not be employed again on any of the work without written consent of the Construction Manager.
3. Contractor and all employees, subcontractors, supporting firms and incidental labor shall meet the minimum safety requirements for the Owner's facilities.

I. Final Clean Up

1. Upon completion of the work and before acceptance and final payment is made, the Contractor shall clean, remove rubbish and temporary structures from the site, restore in an acceptable manner all property which has been damaged during the prosecution of the work and leave the site of the work in a neat and presentable condition throughout.

J. Final Inspection

1. Whenever the work provided for in, and contemplated under, the contract has been satisfactorily completed (with the exception of any performance periods) and the final clean up performed, the Contractor shall notify in writing to the Construction Manager to make the "Final Inspection". Such inspection will be made as soon as possible, but not longer than (10) days after such notification. After such final inspection, if the work is found to be satisfactory (with the exception of any performance periods), the Contractor will be notified in writing of the acceptance of same. The "Final Acceptance" will not release the Contractor from responsibility for all items, materials, or equipment requiring performance test periods or final measurements unless otherwise shown in the contract.

1.3 SUMMARY OF WORK

A. General

1. The Contractor shall work closely and communicate regularly with the Owner in order to minimize conflicts and expedite the completion of the work. The Construction Manager serves as the Owner's representative.
2. All equipment and materials on-site during the work will be the responsibility of the Contractor. The Owner shall not be responsible for theft, vandalism or damage to any of the equipment or materials.
3. Contractor shall be required to prepare and adhere to a Quality Control Plan for field installation, as approved by the Construction Manager.
4. Contractor shall select and pay for an independent laboratory(ies) as required for testing materials and product.
5. Contractor shall adhere to all health and safety requirements as identified in the Site Health and Safety Plan and as required by Plant and Solutia corporate safety requirements.
6. Contractor shall prepare and submit for approval by the Construction Manager all Work Plans, Safety Plans, and Construction Plans as required by these Specifications.

B. Work Covered by Contract Documents

- Mobilization to site

- Site preparation to include clear and grub (if necessary), installation of temporary facilities, erosion control, access road development and stormwater management measures
- Construction of wells and piezometers
- Installation of well pumps, piping and appurtenances
- Installation of the vertical barrier wall
- Handling construction spoils, construction of a temporary spoil stockpile
- Chain link fencing and gates
- Management of stormwater and construction water
- Electrical power and controls
- Site restoration, including grading and reseedling as required
- Demobilization from the site

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

Not used.

END OF SECTION

SECTION 01500

MOBILIZATION AND TEMPORARY FACILITIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Mobilization
- B. Temporary Facilities

1.2 WORK INCLUDED

- A. The work to be performed under this section, includes the mobilization of all equipment, material, temporary facilities and personnel required to perform the work detailed in this contract.
- B. Administrative expenses required to meet the contract conditions, such as insurance, permits, etc. are included in this task.

1.3 SUBMITTALS

- A. Prior to beginning work, Contractor shall submit a plan for the Construction Manager's approval, showing the proposed locations of haul roads and access roads.
- B. Contractor shall submit a plan to the Construction Manager, for approval, showing all proposed laydown areas, storage areas, construction support facilities (trailers) and equipment and vehicle parking areas.

PART 2 - PRODUCTS

Not used

PART 3 - EXECUTION

3.1 MOBILIZATION

- A. Contractor shall commence mobilization within fourteen (14) days following receipt of Notice to Proceed, and shall complete mobilization within the time allocation shown on the Contractor's construction schedule.
- B. Contractor shall provide traffic controls, including flaggers as necessary, for safe and efficient use of the access and haul roads. Contractor shall provide flaggers and

controls as necessary to **prevent** construction traffic from interfering with public and private traffic.

3.2 TEMPORARY FACILITIES

- A. Contractor shall provide for onsite trash dumpster to centralize collection and removal of incidental construction debris, rubbish and other trash.
- B. Contractor shall coordinate **and** maintain all utilities that he deems are necessary to conduct the work. Telephone service, electrical power and potable water are not available at the construction area.
- C. Contractor shall provide all **necessary** sanitary facilities in accordance with applicable laws and requirements. This **may** include portable toilet units or temporary sanitary sewage holding tanks. Transport and disposal of sanitary sewage from the construction site will be included in the Contractor requirements.
- D. All temporary buildings (trailers, sheds etc.) shall be properly secured in accordance state and local ordinance requirements.
- E. Contractor will maintain the site in a clean, uncluttered and safe condition during all phases of the work.
- F. Site security for all construction equipment, facilities and personnel shall be the responsibility of the Contractor.
- G. Contractor shall provide for a centralized fueling station(s), approved by the Construction Manager, for all construction and auxiliary equipment. This location shall be no closer that 25 feet from inhabited buildings. Fuel storage tanks shall be properly grounded, with spill prevention and containment as required by state and local ordinance. Fueling of equipment outside of the designated fuel station areas is not permitted.
- H. Contractor shall coordinate through the Construction Manager all deliveries, service providers and/or approved visiting personnel required to conduct the work. Access to the site will be denied to all persons not in compliance the Solutia Plant Access Procedures.

END OF SECTION

SECTION 01550

SITE PREPARATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Surveying Services
- B. Utilities Relocation
- C. Utilities Installation
- D. Access Roads
- E. Construction Staging and Work Areas

1.2 DEFINITIONS

- A. Land Surveyor: Surveyor shall be a registered land surveyor in the State of Illinois and acceptable to the Construction Manager.
- B. Record Documents: All information collected by Surveyor.
- C. Utilities: Water, electrical power and telephone services.

1.3 SUBMITTALS

- A. Contractor shall submit name, address, and telephone number of Surveyor to the Construction Manager before starting survey work.
- B. On request of the Construction Manager, Contractor shall submit documentation verifying accuracy of survey work.
- C. Contractor shall submit certificate signed by Surveyor certifying that elevations and locations of site constructed features are in conformance, or non-conformance, with the Contract Documents.
- D. Contractor shall be responsible for coordinating the location, relocation and restoration of all site utilities, required by the work. All such activities require approval by the Construction Manager. Contractor shall secure the usage of onsite utilities and shall be billed directly by the service provider.
- E. Contractor shall prepare and submit a Site Preparation Plan clearly showing all proposed locations for staging and storage areas, temporary access roads, temporary

structures, temporary utilities, vehicle parking and any modifications to the existing site conditions. Only contractor owned vehicles, required to conduct the work, will be allowed past the project vehicle parking area(s).

- F. All disturbed surface areas shall be managed in such fashion as to prevent erosion and control water and sediment transport. Such measures may include silt fencing, straw bales, rock check dams, and/or erosion control mats.
- G. All construction permits, building permits or work notifications required by state or local government agencies shall be obtained or conducted by the Contractor. All regulatory and environmental permits will be secured and maintained by the Owner.
- H. The Owner will provide a fenced, locked-gate site. Contractor shall be responsible for security and protection of all elements of the work at the site.
- I. Contractor shall coordinate and prepare the site in a manner that promotes efficient and safe delivery of materials with no disruption to existing businesses or site conditions.

1.4 PROJECT RECORD DOCUMENTS

- A. Contractor shall maintain on site a complete, accurate log of control and survey work as it progresses.
- B. Upon completion of the work or as requested by the Construction Manager, Contractor shall submit Record (as-built) Documents to the Construction Manager.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Contractor shall verify locations of site reference and survey control points prior to starting work. Contractor shall promptly notify the Construction Manager of any discrepancies discovered.

- B. All modifications to the site, either temporary or permanent, require written approval by the Construction Manager.

3.2 SURVEY REFERENCE POINTS

- A. Contractor shall protect survey control points prior to starting sitework and preserve permanent reference points during construction. Contractor shall not relocate site reference points without prior written approval by the Construction Manager.
- B. Contractor shall promptly report to the Construction Manager the loss, damage, or destruction of any reference point or relocation required because of changes in grades or other reasons. Contractor shall replace dislocated survey control points based on original survey control at no cost to the Owner.

3.3 SITE REQUIREMENTS

- A. Contractor shall maintain the site in a clean and safe condition for the duration of the work.
- B. Unauthorized persons will not be allowed access to the site. Contractor shall provide the Construction Manager with a list of all personnel, suppliers, and vendors that will regularly enter and leave the site. Contractor shall notify the Construction Manager of visitors or any change in site personnel.
- C. Contractor shall install and maintain all sanitary facilities required for the work. Fuel transport, delivery and storage shall be in conformance with all applicable state, federal and Solutia Inc. requirements.
- D. Contractor shall provide and maintain dumpsters, roll off boxes or other trash and debris containers needed to conduct the work.

3.4 SURVEYS FOR CONTRACTOR QUALITY CONTROL

- A. Contractor shall perform surveys to determine as-built elevations of all components of the project as required by the Specifications and the Contractor's Quality Control Plan and shall notify the Construction Manager prior to starting the work.

END OF SECTION

SECTION 01700

DEMOBILIZATION & PROJECT CLOSEOUT

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The work to be performed under this section includes the decontamination and removal of all Contractor's equipment, materials, temporary facilities and personnel from the project site and the restoration of all areas used for offices, parking, staging and storage.
- B. Project Closeout will follow notification to the Construction Manager, by Contractor, that the work is substantially complete.

1.2 SUBMITTALS

- A. Contractor shall submit the following to the Construction Manager prior to demobilization:
 - Warrantees / Guarantees
 - Certificates of Inspection
 - Operating Manuals and Instructions (if applicable)
 - Record (as-built) Drawings
 - Inspection/Compliance Certificates and Permits issued by local agencies
 - Final Waivers of Liens
 - Documentation and/or Verification as may be requested by the Construction Manager
 - Equipment Decontamination Records
- B. Contractor shall submit a schedule at least three (3) weeks in advance of anticipated demobilization and project closeout. This schedule is to include the sequence and timing of all activities associated with moving equipment, facilities and materials. It is to include all preparation and coordination required to remove Contractors facilities from the Solutia property.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.1 DEMOBILIZATION

- A. Contractor shall remove **all temporary** facilities, equipment, and materials used to conduct the work. The **site shall** be graded to required elevations, cleaned, and restored to the original conditions.
- B. Contractor shall remove **and dispose** of any collected sediment from erosion control devices.
- C. All temporary utilities **installed by the Contractor** shall be disconnected and removed.
- D. Contractor shall replace or **repair** existing plant facilities that were temporarily relocated, closed, or otherwise **impacted** during the work.
- E. Contractor shall restore **all decontamination** areas to original site conditions.

3.2 CLOSEOUT PROCEDURES

- A. Contractor shall notify the **Construction Manager** that the Contract is substantially complete and is ready for **inspection** a minimum of five (5) working days prior to the desired date of the final inspection. Following completion of the site inspection, by the **Construction Manager**, **notification** will be given to the Contractor, in the form of a **Punchlist**, of items to be completed or corrected. Contractor shall remedy deficiencies and send a **notice of final completion**, as detailed in Subsection 3.3.

3.3 FINAL COMPLETION

When Contractor considers the work to be complete, written certification will be submitted to the **Construction Manager** that:

- A. The **Contract Documents** have been reviewed.
- B. The work has been **inspected** by the **Construction Manager** for compliance with the **Contract Documents**.
- C. Deficiencies **identified in the Punchlist** have been inspected and corrected.
- D. The work is **complete and ready** for final walk-through.

After a final walk-through by the **Owner, Engineer, and Construction Manager**, Contractor will be notified in **writing** of any incomplete or defective work.

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Contractor shall remedy deficiencies and send a second notice of completion, and the work will be re-examined. This procedure shall continue until Owner, Engineer, and Construction Manager approvals are obtained.

3.4 FINAL PAYMENT

A. Contractor shall submit his invoice for final payment in accordance with the contract procedures.

END OF SECTION

SECTION 02100

EROSION AND STORMWATER CONTROL DURING CONSTRUCTION

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Preparation and implementation of a Storm Water Pollution Prevention Plan (SWPPP).
 - 2. Implementation of Best Management Practices (BMPs) for storm water run-on and run-off.
 - 3. Control of wind blown dust.
 - 4. Design, construction, operation and maintenance of a storm water collection system.
- B. Contractor shall schedule and conduct its operations to minimize erosion of soils. The area of bare soil exposed at any one time by construction operations shall be kept to a minimum.
- C. The Owner will provide a storm water treatment system.

1.2 SUBMITTALS

- A. A site specific SWPPP.
- B. A plan to control storm water run-on from off site.
- C. A plan to control wind blown dust.
- D. A design for a storm water collection system, including an operations and maintenance manual.
- E. Location and specifications for any borrow materials.

PART 2 - PRODUCTS

2.1 SWPPP

- A. A SWPPP shall be prepared that meets the requirements of the National Pollutant Discharge Elimination System (NPDES) and the State of Illinois.
- B. The SWPPP must address all areas disturbed by the construction including, but not limited to the barrier wall, temporary stockpile, extraction wells and related well head equipment, and effluent pipeline.

2.2 RUN-ON CONTROL PLAN

- A. The Plan shall be prepared to **prevent** run-on of storm water from off site during the peak discharge from a 25-year storm.
- B. The Plan must include the **area of the barrier wall**, temporary stockpile, extraction wells and related well head equipment, **and effluent pipeline**.
- C. The Plan must segregate the **stormwater** run-on from rain that comes in contact with spoils from the excavated areas, from areas that are not impacted by excavated materials.
- D. Run-on stormwater may be **diverted** directly to the drainage facilities that drain into the Mississippi River.

2.3 WIND BLOWN DUST PLAN

- A. The plan shall address how wind blown dust will be controlled.
- B. The Plan must include the **area of the barrier wall**, temporary stockpile, extraction wells and related well head equipment, **and effluent pipeline**.

2.4 STORM WATER COLLECTION SYSTEM

- A. The collection system must be **capable** of collecting the water volume resulting from a 24-hour 25-year storm and **delivering** the runoff to a treatment system provided by the Owner on site. Rainfall from **areas that** are not impacted by excavated materials are not included.
- B. The Plan must include the **area of the barrier wall**, temporary stockpile, extraction wells and related well head equipment, **and effluent pipeline**.
- C. The Owner will provide, **operate and maintain** the storm water treatment system.

2.5 EARTH FILL

- A. The borrow material shall be a **clean** low plastic clay, CL classification per ASTM D2487. In addition, a plasticity **index** of 7 or greater is required.

PART 3 - EXECUTION

3.1 EXECUTION - GENERAL

- A. Construct the systems **described** herein in accordance with the approved plan submittals.
- B. Implement the systems **described** herein accordance with the approved operations and maintenance manuals.

- C. Should conditions warrant revisions to the approved plans and manuals, obtain the Owner's approval for modifications before making changes.
- D. Be prepared to respond to emergencies and have a plan to address unusual conditions.

3.2 EROSION AND STORM WATER CONTROL DEVICES REMOVAL

- A. At the completion of the work, and once the permanent vegetation has been established, remove all erosion and storm water control measures from the site, and re-vegetate all areas disturbed during construction.

END OF SECTION

SECTION 02150
CLEARING AND GRUBBING

PART 1 - GENERAL

1.1 SUMMARY

- A. Furnish labor, equipment and materials as required to clear and grub existing vegetation from the site.
- B. Removal and disposal of vegetation generated by the clearing and grubbing activities.

1.2 MATERIAL OWNERSHIP

- A. Cleared materials shall become Contractor's property and shall be removed from project site.

1.3 SUBMITTALS

- A. Contractor shall submit a Clearing and Grubbing Plan that is consistent with the selected locations for the construction areas and temporary haul road(s).

1.4 PROJECT CONDITIONS

- A. Authority for performing site clearing indicated on property adjoining the Owner's property will be obtained by the Owner before award of Contract. Do not proceed with work on adjoining property until directed by the Owner.
- B. Notify utility locator service for area where Project is located before site clearing.
- C. Do not commence site-clearing operations until temporary erosion and sedimentation control measures are in place.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect and maintain benchmarks and survey control points from disturbance during construction.
- B. Locate and clearly flag trees and vegetation to remain.
- C. Protect existing site improvements to remain from damage during construction. Restore damaged improvements to their original condition, as acceptable to the Owner.

3.2 CLEARING AND GRUBBING

- A. Remove obstructions, trees, shrubs, grass, and other vegetation to permit installation of new construction.
- B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated. Place fill material in horizontal layers not exceeding a loose depth of 8 inches, and compact each layer to a density equal to adjacent original ground.

3.3 SITE IMPROVEMENTS

- A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.
- B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
 - 1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.
 - 2. Paint cut ends of steel reinforcement in concrete to remain to prevent corrosion.

3.4 DISPOSAL

- A. Remove unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off the Owner's property.
- B. Burning on site is not permitted.

END OF SECTION

SECTION 02190
TEMPORARY HAUL ROADS

PART 1 - GENERAL

1.1 SUMMARY

- A. Furnish labor, equipment and materials as specified herein to develop, utilize and maintain temporary haul roads.
- B. Contractor shall be responsible for survey layout, site preparation, excavation, material transfer and maintenance of the haul road(s).
- C. Contractor shall be responsible for constructing temporary haul roads that adequately serve all construction and spoils placement needs throughout the project duration. All road maintenance shall be the responsibility of the Contractor.

1.2 SUBMITTALS

- A. Layout drawings of the proposed locations of temporary haul roads that conform to the requirements of the drawings.
- B. Site access traffic control plan.

PART 2 - PRODUCTS

2.1 HAUL ROADS

- A. Materials used for temporary haul roads is at Contractor's discretion.
- B. All materials must be from sources approved by the Owner.

PART 3 - EXECUTION

3.1 EXECUTION - GENERAL

- A. Construct and maintain the systems described herein in accordance with the approved plan submittals.
- B. Should conditions warrant revisions to the approved plans and manuals, obtain the Owner's approval for modifications before making changes.
- C. Be prepared to respond to emergencies and have a plan to address unusual conditions.

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- D. Temporary cut slopes shall not be steeper than 1 horizontal to 1 vertical. Finished slopes, left for final grading and long-term maintenance, shall not be steeper than 3:1 horizontal to vertical distance.
- E. Contractor shall provide all Traffic and Safety controls as required. This includes, but is not limited to barricades, signs, lights and flagmen and necessary to control and direct traffic to the approved routes.
- F. Effective Dust Control Measures must be employed at all times, in all areas of the work. Contractor shall include any and all dust suppression measures that are necessary for workers health and safety and for the health and safety of persons on or adjacent to the Owner's property. Dust Control Measures may include, but are not limited to: watering spray trucks, approved chemical dust suppressants, road grading, or surface treatments, such as gravel. The Owner will approve all proposed dust control methods and may request additional control measures if site conditions begin to effect visibility, traffic safety or workers breathing areas.
- G. Authority for site access indicated on property adjoining the Owner's property will be obtained by the Owner before award of Contract. Do not proceed with work on adjoining property until directed by the Owner.

3.2 REMOVAL

- A. At the completion of the work, remove all temporary haul roads, fill depressions to restore original grades and re-vegetate all areas disturbed during construction.

END OF SECTION

SECTION 02290

SOIL-BENTONITE BARRIER WALL

PART 1 GENERAL

1.01 DESCRIPTION

- A. Furnish all plant, labor, equipment and materials, and perform all operations as required to design and construct a soil-bentonite barrier wall as shown in the Drawings and specified herein.
- B. The slurry trench shall be a continuous, vertically sided trench excavated through soil supported using slurry. The alignment and minimum depth are indicated on the Contract Drawings.
- C. The contractor shall be responsible for detailed design of the soil-bentonite barrier wall and shall be responsible for the adequacy and performance of the completed barrier wall. The contractor's design shall, as a minimum, meet the requirements of this section.
- D. The work shall include, but not be limited to the following items:
 - 1. Detailed design of the soil-bentonite barrier wall
 - 2. Preparation of a working pad surface, where required.
 - 3. Excavation of slurry trench.
 - 4. Circulation and maintenance of bentonite slurry.
 - 5. Placing soil bentonite backfill in the slurry filled trench as shown on the Drawings.
 - 6. Handling of spoils from slurry wall installation, and managing surface water runoff during construction.
- E. Barrier wall backfill is defined as a mixture of naturally-deposited, on-site and off-site soils (if required) and bentonite slurry proportioned to provide hydraulic conductivity of less than or equal to 1×10^{-7} cm/sec when mixed to a homogenous consistency and placed within the excavated slurry trench in a controlled manner. The controlled laboratory mix design for the proportioned backfill mix shall be a maximum of 5×10^{-8} cm/sec. The on-site soil material shall be excavated from the slurry trench and off-site soil material (if required) shall be brought to the site from an approved off-site source. The maximum allowable particle size in the backfill is 3 inches.

- F. The depth of the slurry wall has been estimated from the borings taken during the Pre-Design Investigation. Some variation of the depth is to be anticipated. The slurry wall shall penetrate the overburden down to top of bedrock.
- G. The Contractor shall submit evidence that his firm or competent in slurry trench construction. The Contractor shall have a minimum of five years of experience in slurry trench construction to similar depths and in similar materials as this project and have knowledge in all aspects of soil-bentonite slurry trench construction. Two projects which each had installations of at least 30,000 cubic yards of wall volume shall be included.
- H. The Contractor shall submit qualifications of key personnel including, design engineer, and field personnel proposed for work performed pursuant to this specification. Key personnel shall be experienced in the design and construction of soil-bentonite barrier walls and the proposed superintendent must have completed at least one project for the Contractor.
- I. The Contractor's Design Engineer shall have at least 5 years experience in design of soil-bentonite cutoff walls and shall be a Registered Professional Engineer in Illinois.

1.02 DEFINITIONS

- A. A slurry wall as referred to herein is a wall of the minimum dimensions shown on the Drawings, excavated through the existing soils to top of bedrock by the slurry trench method of excavation, and backfilled with a soil-bentonite mixture to form a seepage barrier. The wall must be resistant to cracking and erosion.
- B. The slurry trench method of excavation consists of excavating a trench in the existing soils while at the same time keeping the trench filled with bentonite-water slurry. The basic purpose of the slurry is to maintain the stability of the walls of the trench.
- C. Slurry is a stable, colloidal, thixotropic suspension of powdered bentonite in water.
- D. Bentonite is a natural clay whose principal mineral constituent is sodium montmorillonite.
- E. Slurry Loss is a drop of the slurry surface in the excavation of 5 feet or more in a time period of 30 minutes or less not resulting from removal of excavated material.
- F. Surface water is all water that enters the work area above the ground surface from either natural or artificial sources.
- G. Groundwater denotes all water below the existing ground surface within the work area.
- H. The working pad is the surface on which the equipment shall operate to construct the wall. The elevation of this surface along the alignment of the trench shall be such

that it does not cause slurry in any part of the open trench to be more than 2 feet below the top of the trench or less than 5 feet above groundwater level.

- I. Soil-bentonite is a low **strength** mixture of soil and bentonite-water slurry. The soil used to make the backfill **may be** taken from the excavation spoils.
- J. Engineer is the **representative** of the Owner who will review the contractor's work, provide **Quality Assurance** of the contractor's work , and judge whether the completed work is **acceptable**.
- K. The Contractor's **Design Engineer** is the engineer who will perform the detailed design of the soil-bentonite **barrier** wall, and prepare and seal the final design. He shall be the engineer of **record** for the soil-bentonite barrier wall.

1.03 REFERENCE STANDARDS

A. American Society for Testing Materials (ASTM)

- 1. ASTM C143 **Standard** Test Method for Slump of Hydraulic-Cement Concrete.
- 2. ASTM D422 **Standard** Test Method for Particle-Size Analysis of Soils.
- 3. ASTM D 2166 **Standard** Test Method for Unconfined Compressive Strength of Cohesive Soils.
- 4. ASTM D2216 **Standard** Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
- 5. ASTM D4318 **Standard** Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
- 6. ASTM D 4380 **Standard** Test Method for Density of Bentonite Slurries.
- 7. ASTM D5084 **Standard** Test Method for Measurement of Hydraulic Conductivity of **Saturated** Porous Materials Using a Flexible Wall Permeameter.

B. American Petroleum Institute (API)

- 1. API Specification 13A Specification for Oil Well Drilling Fluid Materials.
- 2. API Recommended Practice 13B Standard Procedure for Testing Drilling Fluids.

- C. Where reference is made to one of the above standards, the revision in effect at the time of work shall apply.

- D. In the event of a conflict between this Specification and the referenced standards, this Specification shall govern.

1.04 SUBMITTALS

- A. Submit four copies of a **Barrier Wall Construction Plan**. Submit a minimum of 2 weeks prior to the start of barrier wall construction. The Construction Plan shall include four copies of the barrier wall design including sealed construction plans, specifications, and calculations. The plan should include drawings and written text as necessary to clearly indicate the following:
1. Proposed wall construction sequence and anticipated schedule, including description of corner construction and any revisions to meet backfill material properties required for corner construction. A detailed construction schedule shall be submitted indicating a detailed critical path schedule which includes mobilization, work pad preparation, guide wall construction, slurry wall construction, and anticipated contingencies to assure the project schedule is met. The submittal shall indicate production rates and shift schedules needed to meet the project requirements.
 2. Proposed slurry mixing, and pumping equipment. The barrier wall backfill mix design shall be selected by the Contractor. Successful barrier wall backfill design testing and documentation including hydraulic conductivity and chemical compatibility testing will be required for backfill mixes prior to use on the site. Chemical compatibility test data for the existing site conditions will be provided to the Contractor by the Owner.
 3. Proposed trench excavation equipment.
 4. Proposed trench backfill mixing and placement equipment and procedures including method for confirming top of rock and excavation depths.
 5. Detailed contingency plan outlining steps to be followed in the event of excessive slurry loss. The plans shall also include method to be used to treat excessive slurry loss, (grouting, etc.).
 6. Proposed method(s) to prevent bentonite slurry from entering nearby water courses or sewer lines in the event of slurry loss.
 7. Documents certifying the properties of bentonite and other materials. At the Owner's request, the Contractor shall furnish samples of any other materials in sufficient amount for independent quality control testing.
 8. Documentation that the off-site borrow soil (if required) proposed by the Contractor for use in preparing the barrier wall backfill is free of man-placed materials, oils or other potentially hazardous materials.

9. Results of geotechnical index property testing (gradation per ASTM D422 and Atterberg Limits per ASTM D4318) conducted on the off-site borrow soil proposed by the Contractor for use in preparing the barrier wall backfill, if off-site borrow soil is required.
 10. Calculations of proposed slurry trench stability used by the Contractor as the basis for selecting the proposed minimum slurry elevation.
 11. Proposed truck traffic patterns and bentonite stockpile areas and hydrating ponds and equipment decontamination area. Include locations and design of temporary slurry trench/barrier wall crossings by trucks and other construction equipment.
 12. Contractor's Quality Control Plan including sample quality control test and measurement forms to be completed by the Contractor during construction; description of quality control testing equipment and procedures, and off-site testing laboratory proposed for use.
 13. Proposed excess soil and slurry disposal and site cleanup procedures. Excess water is to be dried off prior to placement of material in the temporary stockpile shown on the drawings.
- B. Submit results of construction quality control testing, trench depth measurements and daily field reports during construction. Daily field reports should contain the following:
1. Day, month, year, time of work sights (beginning and end); list of all workers names, equipment used, and major deliveries.
 2. The location of completed barrier wall installed during the work shifts and all barrier wall portions completed to-date on a plan of suitable scale not smaller than 1 inch = 10 feet.
 3. Other pertinent observations including, but not limited to: slurry loss; ground settlement and/or heave; collapses of the barrier wall; and any unusual behavior of any equipment during the process.

4. Summary of any downtime or other unproductive time, including time, duration, and reason.
 5. Certificate for each truck load delivery of bentonite.
 6. Quantity of bentonite and other materials used that day.
 7. All laboratory test results.
 8. The Contractor shall submit Daily Quality Control Reports at the end of the next working day.
- C. Prepare and submit four copies of a construction quality assurance report after completing barrier wall construction that includes the results of construction quality control test results, trench depth measurements, and record barrier wall surface elevation and wall alignment surveys conducted by a Land Surveyor registered in the State of Illinois, documenting that the wall was constructed in accordance with the Drawings and Specifications.

1.05 METHOD OF MEASUREMENT

- A. Soil-bentonite slurry walls, complete in place, will be measured by the number of square feet of wall based on the design elevations as shown on the Drawings (measured on the vertical surface). Verification of trench bottom elevations will be performed during the installation of the soil-bentonite slurry wall.

1.06 BASIS OF PAVEMENT

- A. Payment will be made on the basis of actual validated costs plus an agreed-to Fixed Dollar Fee. The Fee will be paid on a prorated basis consistent with the project monthly completion schedule not to exceed 50% of the total value of the Fee. Following final acceptance of the work, the remaining 50% of the total Fee will be paid in a single payment.

1.07 QUALITY CONTROL AND ASSURANCE

- A. Additional testing, measurements and observations as described for quality control, will be conducted by the Engineer for purposes of quality assurance. The Contractor shall cooperate with the Engineer in conducting quality assurance testing.
- B. The Contractor shall provide quality control measures as necessary to assure that the barrier wall is constructed in a manner that satisfies the performance requirements set forth by the Contractor's design engineer, and these Specifications. Quality control measures shall be implemented by the Contractor during the construction sequence to avoid defects in the finished wall that would reduce the effectiveness of the barrier. These measures shall include but are not limited to visual observations and

measurements by the Contractor's experienced personnel on the excavation and backfilling procedures, trench depths and alignment, barrier continuity, and testing of slurry and backfill, as necessary, to provide a barrier wall meeting these Specifications. The Contractor is required to perform quality control testing in accordance with his Quality Control Plan, these Specifications, and CQAP; and to provide the Engineer with the results of quality control testing, measurements and documentation of observations on a daily basis.

PART 2 MATERIALS

2.01 ADDITIVES

- A. Additives such as dispersants, plugging agents, and/or softeners may be added to the water or slurry so as to obtain proper workability of the slurry and efficient use of the bentonite. Additives to the slurry must be approved by the Engineer and the EPA prior to use.

2.02 BENTONITE

- A. Bentonite used in preparing the bentonite-water slurry and soil bentonite backfill mix shall be sodium montomorillonite bentonite, Fed Jel 90 (FJ-90) or approved equivalent. If FJ-90 is not used, the Contractor shall perform laboratory testing to demonstrate equivalency (at his cost). Bentonite shall meet the latest version of API Standard 13A "Specification for Oil Well Drilling Fluid Materials."

2.03 WATER

- A. Water used for the slurry and barrier backfill mixing shall be from the local potable water source. The mixing water shall be free of deleterious substances, leachate, or oil and grease that may adversely affect the properties of the bentonite slurry. Mixing water supply shall be tested weekly by the Contractor for the properties listed here with the results submitted to the Engineer. The water shall exhibit a pH in the range of 7 (± 0.5), shall have a total hardness less than 300 ppm, and shall have total dissolved solids below 500 ppm. The water shall be tested weekly for conductivity as well.

2.04 SOIL

- A. The material to be used for backfill shall be composed of slurry, sand, silt and clay and may be obtained from the trench excavation or from borrow sources approved by the Owner. Soil particles equal to or larger than 3 inches in diameter shall be separated and removed from the on-site soils and stockpiled in the designated excess soil area shown on the Drawings. The on-site soils shall also be free of roots, rubbish, organics, or other foreign matter which could be detrimental to the backfill mix.

- B. Soil used to construct working pad surfaces and control berms along the trench alignment will be excavated from on- or off-site borrow sources. In areas where only berms are required, minimal surficial excavation is allowed along the trench alignment to mine adequate borrow soils for berm construction. The Contractor shall use the borrow source area nearest to the location of the ongoing slurry wall construction to minimize traffic.

2.05 SLURRY

- A. The bentonite-water slurry shall be prepared by mixing powdered bentonite with water in a high-speed colloidal or venturi-type flash mixer which achieves complete dispersion of the bentonite particles. The bentonite slurry shall be fully hydrated for a minimum of 30 minutes after mixing in the mixed before introduction into the trench. The slurry shall be maintained in holding pits or tanks and agitated to hold all particles in suspension. Prior to pumping into the trench, the slurry shall be required to be tested for the following from A.P.I. Recommended Practice 13-B1. Minimum or maximum values shall be determined by the contractor's design engineer based on site conditions: percent bentonite (by weight), slurry unit weight, apparent viscosity, rate of filtrate loss, and pH.

Testing to verify that these requirements have been met shall be performed by the Contractor.

- B. Slurry within the trench shall be monitored for consistency in accordance with A.P.I. Recommended Practice 13B-1. Minimum or maximum values for the following parameters should be stated in the Contractor's design: pH, unit weight, and apparent viscosity.

Testing to verify that these requirements are followed shall be performed by the Contractor. Immediately adjust the slurry properties if measurements indicate variations from these requirements. The contractor shall be responsible for maintaining the stability of the trench excavation. Weighting agents may be used to increase the density of the slurry if necessary to maintain trench stability.

- C. The dry bentonite will need to have a manufacturer's certification that the bentonite meets the following API 13A requirements:

Viscosity	30 min @ 600 rpm
Filtrate Volume	15 cm ³ max
>75 Micron	4 % wt max
Moisture	10% wt max
Yield Point/Plastic Viscosity	3 max

2.06 BARRIER WALL BACKFILL

- A. Backfill introduced into the trench shall be a stable, homogeneous mixture of soil excavated from the trench with maximum particle size less than 3 inches, imported soil from the off-site borrow (if necessary) and slurry and dry bentonite if necessary. Other materials proposed by the Contractor will be considered but must be approved by the Engineer. The backfill mix shall be designed by the contractor and submitted to the Engineer for approval. The resulting mix shall have a hydraulic conductivity less than or equal to 1×10^{-7} cm/sec. The trial mix should have an hydraulic conductivity of 5×10^{-8} or less. Testing for hydraulic conductivity of the backfill material will be per ASTM D 5084 on backfill samples before installation. All backfill shall be mixed at a location adjacent to the trench. Mixing of backfill with slurry in the trench shall not be permitted. The Contractor will demonstrate to the Engineer the suitability of the backfill mix before placement.

2.07 EQUIPMENT

- A. The Contractor shall operate a slurry plant consisting of a bentonite storage facility, high speed colloidal or venturi-type flash mixer, slurry mixing and hydration tanks or pits. The tanks or pits shall have ample storage capacity to allow hydration time and serve as a reservoir in case of rapid slurry loss. The slurry shall be agitated or recirculated in the tanks. No slurry shall be made in the trench excavation.
- B. The Contractor shall provide sufficient numbers and types of excavating equipment such as a trackhoe and clamshell to complete the project within the schedule. Equipment shall be special slurry trench excavating equipment or combinations of equipment capable of accommodating a slurry wall construction.
- C. The soil bentonite backfill shall be mixed with heavy equipment next to the wall alignment. No backfill mixing will be allowed in the trench.

PART 3 EXECUTION

3.01 GENERAL

- A. The slurry wall shall be constructed to the lines and elevations shown on the Drawings, unless otherwise authorized by the Engineer.
 - 1. The slurry wall shall penetrate the subsurface soils to the elevations shown on the Drawings. The slurry wall will penetrate the bedrock 1-foot or refusal. (Boulders will not be considered bedrock.)

2. After the trench excavation reaches the accepted elevation, the Engineer and Contractor shall measure and document the actual wall elevations.
- B. Width: The minimum width of the soil-bentonite slurry wall will be determined by the width of the required excavating equipment, but shall not be less than 30 inches wide at any point along the wall's elevation.
- C. The horizontal alignment shall be as shown in the Drawings.

3.02 SITE PREPARATION

- A. Prepare the barrier wall trenching area and staging areas as described in this paragraph.
- B. Remove existing concrete pavement and ground cover within the lateral limits of the barrier wall area. Limits of the work area shall be as shown on the Drawings. Install and maintain survey stakes in appropriate locations along the trench to identify 100-foot station locations along the trench. These stakes will be referenced for quality control and quality assurance measurements during trench construction.
- C. Contractor shall have suitable earth trenching equipment such as a backhoe and/or clamshell so that the required width of trench can be carried to its final depth of cut continuously along the trench alignment line. Additional equipment such as air lift pumps and slurry desanders shall be provided by the Contractor, to clean the slurry in accordance with the requirements of these Specifications. Impact drills or chisels shall be available as necessary for breaking and removal of boulders and/or dense soil layers from the trench.
- D. The slurry batching plant shall include the necessary equipment including a mixer capable of continuously producing a homogenous colloidal suspension of bentonite in water, pumps, valves, hoses, supply lines, and other equipment as required to adequately supply slurry to the trench and to adjust the pH of the slurry as necessary. The slurry shall be agitated or recirculated in storage ponds or tanks as required to maintain a homogeneous mix. No slurry is to be made in the trench. Mixing of water and bentonite shall continue until bentonite particles are fully hydrated and the resulting slurry is homogeneous. Storage ponds or tanks shall be provided by the Contractor to store freshly mixed slurry during hydration, and to serve as a reserve supply of slurry in the event of slurry loss from the trench.
- E. Equipment and methods, for processing, mixing and placing backfill shall include suitable means of separating particles 3 inches in diameter and larger from the excavated on-site soil, a suitable type of earthmoving or grading machine, such as a bulldozer, motor grader, power harrow, or pug mill blender that is capable of thoroughly mixing the backfill materials into a homogeneous mix having the required properties, and suitable earthmoving or grading equipment for placing the material in the trench as hereinafter specified.

- F. The Contractor shall have available the equipment necessary to test the fresh bentonite slurry, in-trench slurry, and soil-bentonite backfill mix including a pH meter, slump cone, Marsh funnel, filter press, mud balance, slurry sampler, and any other equipment required to adequately assess the properties of the slurry and backfill.
- G. Three extraction wells have been installed and will be operational at the time of the barrier wall installation. In addition, eight piezometers have been installed. Four of the piezometers will be operational at the time of the barrier wall installation (P-1E, P-2E, P-3E, and P-4E). The piezometers are located approximately 15 to 20 feet from the centerline of the new barrier wall. Conduit will be installed to connect the piezometers and extraction wells. This conduit will be marked in the field. It will be the Contractor's responsibility to avoid damaging the wells, piezometers, and conduit and cable. Any damage caused due to construction activities will need to be repaired or replaced at the Contractor's expense.

3.03 SLURRY TRENCHING

- A. The Contractor shall provide labor and equipment sufficient to operate excavation equipment during routine construction of the slurry wall. Adequate replacement equipment and maintenance and supervisory support shall be provided to minimize equipment downtime and maintain the construction schedule. Excavation of the slurry trench shall be performed as outlined below.
 - 1. The Contractor shall excavate the slurry trench in a continuous manner, carrying the excavation to the full depth required at the point where work is started and carrying the required depth along the line of the trench for each trench segment. Slurry shall be introduced into the trench at the same time trenching is begun and shall be maintained in the trench during excavation and until backfilling has been completed. The Contractor shall maintain the stability of the excavated trench at all times for its full depth. The level of the bentonite slurry shall be maintained within 2 feet of the work platform surface, except as approved by the Engineer to maintain the stability of the trench. The Contractor shall have personnel, equipment, and materials ready to raise the slurry level at any time. To this end, the Contractor shall have personnel on call to raise the slurry level at all times, weekends and/or holidays included. The Contractor shall provide the Engineer for review and approval the proposed method to construct the intersection of the walls. This submittal shall be provided at least 10 days prior to commencing trench excavation.
 - 2. Bentonite slurry introduced into the trench shall be mixed and handled as specified herein. Soil excavated from the trench which is suitable for backfill shall be stockpiled on the working platform for blending with off-site soil borrow material (if required) and slurry. Such stockpiles shall not be placed within 25 feet of the open trench, or further as necessary to maintain trench

stability. The Contractor shall separate cobbles greater than or equal to 3 inches in diameter from the excavated soil stockpiles. Cobbles greater than or equal to 3 inches in diameter shall be excluded from the soil-bentonite trench backfill. In addition, the Engineer may require the Contractor to segregate soils with visible signs of contamination, or soils with unusually high VOC concentrations based on health and safety screening, from soils stockpiled for backfill mixing.

3. The excavation under slurry head shall be carried out in a manner which, when completed, provides a continuous minimum 30-inch wide trench to the required depth for the full length of the trench. The trench shall be excavated to the appropriate bottom elevations shown on the Drawings unless otherwise directed by the Engineer.
4. The Contractor shall be responsible for all costs associated with the implementation of the Contingency Plan in the event of slurry loss or trench collapse. The steps which the Contractor shall take in the event of a slurry loss shall, at a minimum, include increasing slurry viscosity; backfilling trench with stockpiled soils and re-excavating; and use of soil-bentonite backfill and re-excavating. The plans shall also indicate steps to be taken to contain lost slurry.

The Contractor shall maintain a stockpile of suitable materials, such as backfill soils as necessary to be used for emergency backfilling in the event of sudden, rapid slurry loss or used as outlined in the Contingency Plans.

The slurry trench shall be essentially vertical. The working pad and/or excavating equipment shall be leveled to be plumb within 3% of vertical.

5. The Contractor shall cooperate with the Engineer in determining that the bottom of the trench has reached the intended depth and is properly cleaned prior to advancing the excavating equipment. After the trench bottom has been cleaned, the Contractor shall measure the actual excavated depth of trench relative to surveyed stations. Depth measurement frequency shall be every 10 feet unless otherwise directed by the Engineer. Trench bottom cleaning equipment shall be operated in a manner which prevents removal of material from the walls of the trench.
6. The Contractor shall provide a suitable means for determining the depth of trench to within 0.5 foot.
7. The horizontal alignment of the trench must not deviate from that shown on the plans by more than 2 feet unless otherwise authorized by the Engineer. Measurements shall be taken every 50 feet of trenching to verify that the trench meets this tolerance.

8. Excess soil and oversized particles from slurry trench excavation shall be placed in the on-site disposal area.

3.04 SLURRY CONTROL TESTING

- A. Testing of fresh bentonite slurry shall be performed by the Contractor at least twice each day or as directed by the Engineer prior to introduction into the trench. Testing shall include the following:

- temperature
- pH
- unit weight (API 13B-1)
- viscosity (API 13B-1)
- filtrate loss (API 13B-1)

Verbal test results shall be provided immediately to the Engineer and written test results shall be provided to the Engineer within 24 hours of testing.

- B. Slurry from the bottom of the trench at the toe of the backfill slope and at the point of trenching shall similarly be tested by the Contractor at the beginning and end of each 8-hour work shift for the following properties:

- temperature
- pH
- unit weight (API 13B-1)
- viscosity (API 13B-1)

Verbal test results shall be provided immediately to the Engineer and written test results shall be provided to the Engineer within 24 hours of testing.

- C. The apparatus necessary to obtain samples and perform the tests specified above shall be supplied by the Contractor.
- D. The Contractor shall be prepared to immediately adjust the pH of the trench slurry as necessary, recirculate slurry within the trench and clean it of debris or sediment as necessary to achieve the desired properties. In particular, slurry at the bottom of the trench may require recirculation and desanding prior to backfilling the trench with the barrier wall backfill.

3.05 BACKFILL

- A. Backfill Mixing

1. Slurry and the on-site soil shall be mixed and blended in mechanical blenders or by windrowing, bulldozing, blading or by other approved methods. Mixing and blending shall be performed in such a manner as to produce the required properties of the backfill. Pockets of gravel with little to no finer

soils shall be removed and transported to the designated excess soil stockpile area. The Contractor shall manually remove any deleterious materials if required. Deleterious materials may consist of cobbles with 3-inch diameter and larger, organic silts, peat and peat-like material with relatively high organic content. Just prior to placement, the backfill material shall meet the slump, and unit weight requirements determined by Contractor's design engineer. Accurate records of the amount of slurry used in the backfill mix and the slump shall be tabulated per 50 feet of trench and submitted to the Engineer daily. Dry bentonite shall be added and thoroughly mixed into the backfill material to obtain the required backfill properties.

B. Backfill Placement

1. The barrier wall backfill shall be placed continuously from the beginning of the trench, in the direction of the excavation, to the end of the trench. The toe of the slope of the trench excavation shall precede the toe of the backfill slope by not less than 20 feet, or as required to permit inspection and measurement. Placing operations shall proceed such that the surface of the backfill below the slurry shall follow a reasonably smooth grade and shall not have hollows which may trap pockets of slurry during subsequent backfilling. Free dropping of backfill material through the slurry will not be permitted. Initial backfill shall be placed by tremie methods or other method submitted by the Contractor and approved by the Engineer. Initial barrier wall backfill placement will continue until the surface of the backfill rises above the surface of the slurry level at the end of the trench. At the Contractor's discretion, additional backfill placement may continue with the approved method of initial backfill placement or the Contractor may place additional barrier wall backfill above the level of the slurry on the previous barrier wall backfill, thus advancing the existing backfill face. The backfill shall not be dropped or deposited in any manner that will cause segregation. Backfill placement shall be discontinued if the unit weight differential between the in-trench slurry and the barrier wall backfill is less than that specified by the Contractor's design engineer. The toe of the backfill material that rises to the top of the trench at the terminal end of the trench shall be re-excavated as necessary to remove any entrapped slurry, silts, and sands that may exist. This material shall be replaced with new backfill material.

3.06 BACKFILL CONTROL TESTING

- A. As a minimum testing of backfill shall be performed by the Contractor according to the following schedule:
- backfill slump (ASTM C143) and backfill unit weight (API 13B-1) 1 test per 200 cubic yards of backfill
 - backfill gradation (ASTM D422) 1 test per 800 cubic yards of backfill

- Flexible wall hydraulic Conductivity (remolded) (ASTM D5084) 1 test per 2,000 cubic yards
- B. Properties of the bentonite slurry during excavation and prior to backfill placement shall be measured by the Contractor. Samples shall be taken in the trench and at the slurry plant. Quality control tests include Marsh Funnel viscosity, mud balance density, filtrate loss, and pH, as specified by API Standard Procedure RP-13B.
- C. The Contractor is responsible for installation of slurry wall to top of bedrock. In order to verify placement, the Contractor shall make and record depth soundings every 10 feet along the trench centerline. Soundings shall consist of measurement of the depth to the bottom of the excavation immediately after excavating and measurement of depth to the bottom of the excavation immediately before backfilling. Soundings shall be made with a device approved by the Engineer.
- D. In addition, the Contractor shall measure and record the depth to the slope of the backfill at 20-foot intervals at the beginning and end of each 8-hour work shift. If there is an indication of soil accumulation on the backfill slope between the end of a previous shift and beginning of a new shift, the Contractor shall clean the backfill slope to remove the accumulated soil before proceeding with additional backfilling.

3.07 QUALITY CONTROL TESTING

- A. Tests and measurements shall be carried out by the Contractor as specified herein, and data sheets for tests and measurements shall be maintained on a current basis at the job site. Quality control test results shall be made available to the Engineer on a daily basis or more frequently where specified herein. Additional quality control testing shall be performed by the Contractor at the Engineer's request. The Contractor shall assist the Engineer in performance of the quality assurance testing. The Engineer may perform additional tests for quality assurance and documentation purposes and shall be assisted by the Contractor as necessary to make such tests. The Contractor shall provide the Engineer with a quality control report at the end of the project which includes all quality control testing and measurement data and certifies that the barrier wall was constructed in accordance with the Drawings and Specifications.

3.08 POST-CONSTRUCTION MONITORING AND TESTING

- A. Settlement platforms consisting of 2-foot-square by 3/4-inch-thick plywood sheets with a 1-inch-diameter, 30-inch-long steel riser pipe connected to the center of each board shall be installed 18 inches below the surface of the completed trench backfill at 200-foot intervals along the wall within 24 hours of the completion of backfilling within 50 feet of the settlement platform location. A 3-inch-diameter PVC pipe

sleeve shall be installed over the riser pipe from the plywood surface to above the top of the trench backfill to **separate** the riser pipe from the soil-bentonite backfill outside the sleeve.

- B. The elevation of the top of each settlement platform riser pipe shall be surveyed immediately after the platform has been installed and backfilled, then daily thereafter for two weeks, and weekly thereafter until the Engineer indicates that the protective cap installation can begin.

3.09 SITE CLEANUP AND BARRIER WALL PROTECTIVE CAP INSTALLATION

- A. The open trench and barrier wall shall not be crossed by construction equipment except at designated locations which are prepared by the Contractor using a temporary trench crossing designed and constructed by the Contractor.
- B. After completion of slurry trench backfilling, all remaining excavated material and slurry shall be removed from within 25 feet of the barrier wall and the surface shall be cleaned and leveled as directed by the Engineer. No slurry shall be left in pits, and all pits shall be pumped dry and backfilled restored to their original condition. The Contractor shall repair any damage to the completed slurry trench incurred during construction or site cleanup activities. Any such damage shall be immediately repaired by the Contractor in a manner acceptable to the Engineer.
- C. Following excess slurry disposal, excavate the barrier wall to the top of wall elevations indicated on the Contract Drawings. Install clay cap fill as indicated on the Drawings. The Contractor shall allow a minimum of 30 days after completion of trench backfilling or longer if required by the Engineer before constructing the protective cap over the barrier wall.
- D. Areas disturbed during construction shall be graded, compacted, and resurfaced to restore the site to original grade.
- E. The Contractor shall prepare as-built barrier wall plan and profile record drawings (based on level survey and trench depth measurements) similar to those included in the Drawings and provide them to the Engineer as part of the quality control documentation.

END OF SECTION

SECTION 02300

CEMENT SOIL MIXING (CDSM) WALL

PART 1 – GENERAL

1.01 WORK INCLUDED

- A. In accordance with the specifications contained in this Section and as shown on the Plans, the Contractor shall design and furnish all plant, equipment, labor, and materials required to construct Cement Deep Soil Mixing (CDSM) walls, a pre-production test cell and pumping test, and two production test cells and two pumping tests.
- B. The purpose of the CDSM walls is to retard groundwater flow from the Mississippi River in order to reduce the amount of water pumped by the extraction wells. . The CDSM walls consist of a series of continuous walls formed underground using overlapping CDSM columns. The dimensions and layout of CDSM walls are shown on the plans.
- C. The contractor shall be responsible for detailed design, layout, dimensions, overlap of CDSM columns and other details subject to the minimum requirements of this section, and shall be responsible for the adequacy and performance of the installed CDSM barrier.

1.02 REFERENCE STANDARDS

- A. American Society of Testing and Materials (ASTM), latest edition.
 - 1. ASTM C 150: Standard specification for Portland cement.
 - 2. ASTM D 2113 Standard test method for diamond core drilling for site investigation.
 - 3. ASTM D 2166: Standard test method for unconfined compressive strength of cohesive soil.
 - 4. ASTM D 4380: Standard test methods for density of bentonitic slurries.
 - 5. ASTM D 4832: Standard test method for preparation and testing of soil-cement slurry test cylinders.
 - 6. ASTM D 5079: Practices for preserving and transporting rock core sample.

1.03 DESIGN REQUIREMENTS

- A. The design shall follow the alignment shown in the plans and extend from the ground surface to the top of bedrock as shown in the plans. The CDSM Barrier wall shall provide a continuous wall without gaps or voids. The minimum grout

strength and maximum permeability of the CDSM barrier wall shall be as noted in Section 2 of these specifications. Prior to production installation of the CDSM barrier wall, a pumping test shall be run to verify the effective permeability of the CDSM barrier wall.

1.04 QUALIFICATIONS OF CONTRACTOR

- A. The Contractor shall submit evidence that the Contractor is experienced and competent to construct the CDSM walls. This evidence shall show that the Contractor has a minimum of 5 years experience in designing and constructing CDSM walls to similar depths and through similar materials as this project. .
- B. The Contractor shall substantiate this experience with case histories of five or more projects in the past five years showing the independent and successful design and installation of CDSM walls to similar depths than that required for this project utilizing the techniques herein specified. Experience must include at least two projects which each had installations of at least 30,000 cubic yards of soil-cement.
- C. The Contractor shall submit qualifications of key personnel including design engineer, field personnel proposed for work performed pursuant to this specification. Key personnel shall be experienced in the design and construction of in situ CDSM walls and the proposed superintendent must have completed at least one project for the Contractor.
- D. The Contractor's testing laboratory who will conduct tests on soil cement samples shall have received a Satisfactory Rating for the types of tests performed in this contract by AASHTO under the AASHTO Materials Reference Laboratory (AMRL) program within the last 2 years.
- E. The Contractor's Design Engineer shall be a Registered Professional Engineer in Illinois, and have at least 5 years experience in design of CDSM walls.

1.05 DEFINITIONS

- A. CDSM Wall: A soil-cement wall constructed by treating soil in situ by soil-cement mixing technology. The CDSM wall is formed by an arrangement of at least two overlapping soil mixing shafts guided by a lead mounted on a crawler base machine. The mixing shafts shall be driven by a power source sufficient to provide torque for a wide range of drilling conditions and to maintain continuous installation of CDSM walls. As the mixing shafts are advanced into the soil, grout is pumped through the hollow stem of the shafts and injected into the soil at the shaft tips. Auger flights and mixing blades on the shafts blend the soil with grout in a pugmill fashion. When the design depth is reached, the mixing shafts are withdrawn while the mixing process is continued. The mixing shafts are positioned so as to overlap one another to form continuously mixed overlapping

columns. After withdrawal, two (or more) overlapping soil-cement columns remain in the ground. The process is then repeated to form a continuous wall of overlapping columns.

A CDSM Barrier Wall is used to retard seepage. It is a soil-cement-bentonite wall constructed by mixing in situ soil with grout, which is a mixture of water, Portland cement, bentonite and admixtures.

- B. Grout: A Stable colloidal mixture of water, Portland cement, bentonite (for cutoff walls), and admixtures. The purpose of the grout is to assist in loosening the soils for penetration and optimum mixing, to lower the permeability of in situ soils to form a groundwater cutoff wall, and upon setting, to strengthen the in situ soil for greater strength.
- C. Grout-Soil Ratio: A volumetric ratio of grout to in situ soil to be mixed.
- D. Cement Dosage: The amount of cement (in terms of dry weight) used to treat a given volume of in situ soil.
- E. Obstructions: Natural, man-made, or man-placed objects or materials occurring at or below ground surface that substantially prevent the mixing tools from advancing at the at the rate of penetration without the obstruction to the required depths or locations, but without having to use maximum downward force. Obstructions may include, but are not limited to, rubble, utilities, logs/stumps, or boulders.
- F. Engineer: Representative of the Owner who will review the contractor's work, and judge whether the completed work is acceptable.
- G. Contractor's Design Engineer – Engineer who will perform the detailed design of the CDSM barrier wall, prepare and seal the final design. He shall be the Engineer of Record for the CDSM barrier wall.

1.06 SUBMITTALS

- A. Design Documents - Submit to the Engineer four copies of the design documents including drawings, specifications, calculations and related documents at least two weeks prior to construction. The design documents shall be prepared and sealed by the Contractor's Design Engineer. The plans shall include as a minimum the wall thickness, column arrangement, overlap of columns, planned quality control boring locations, pump test details, final wall alignment and wall depth.
- B. Submit four copies of the following to the Engineer at least two weeks prior to commencement of mobilization of production soil-cement mixing equipment to the site:

1. **Grout Mix:** Proposed mix designs including all materials and quantities and documentation of calibration of the mixing plant. Proposed admixtures, if used, should be specified and proposed quantities included.
2. **Construction Schedule:** Submit a detail schedule that identifies start dates and duration of each major task in the work. The schedule should at a minimum include information regarding equipment mobilization, equipment setup, CDSM test section, CDSM production installation, and verification testing.
3. **Equipment and Procedures:** Submit a detail description of the equipment and procedures to be used during all facets of the project including, but not limited to, construction of CDSM walls and test section, pumping test, monitoring the quality control parameters outlined in paragraph 3.09, and collection samples for laboratory confirmation testing. Procedures shall include methods for locating the walls in the field and confirming that the walls are plumb. The Contractor shall also submit the anticipated cement and bentonite dosages to achieve the acceptance criteria outlined in Paragraph 3.09 herein. Details of alternate methods and procedures to install soil-cement mix that may be used in the event of obstructions are encountered shall also be provided.
4. **Sample Daily Quality Control Report:** Prior to construction, submit a proposed Daily Quality Control Report format for approval by the Engineer. Submit the Daily Quality Control Report at the end of each working day. The report shall be in conformance with Paragraph 3.09 herein.
5. **Daily Quality Control Report:** Submit within 24 hours for each day's work. Reporting Requirements are detailed in Paragraph 3.10E herein.
6. **CDSM Samples:** Submit CDSM samples (other than those required for the Contractor testing) as outlined in Paragraph 3.09 herein at the end of each day that the samples are collected.
7. **As-Built Drawing:** Submit as-built drawings prepared by a licensed surveyor indicating the location of the CDSM walls in terms of project coordinates.

PART 2 – PRODUCTS

2.01 MATERIALS

- A. **Grout:** The material added to the blended in situ soils shall be a water-based Portland cement grout or cement-bentonite grout. The purposes of the grout are to assist in loosening the soils for penetration and optimum mixing, to lower the permeability of the in situ soils to form a groundwater cutoff wall (CDSM cutoff walls), and upon setting, to strength the in situ soils. The grout shall be premixed

in a mixing plant which combines dry materials and water in predetermined proportions.

- B. Cement used in preparing the grout shall conform to ASTM C150 "Standard Specification for Portland Cement" Type II. The cement shall be adequately protected from moisture and contamination while in transit to and in storage at the job site. Reclaimed cement or cement containing lumps or deleterious matter shall not be used.
- C. Bentonite: Bentonite shall conform to API Standard 13A "API Specifications for Oil-Well Drilling Fluid Materials." No chemically treated bentonite shall be allowed.
- D. Water: Fresh water, free of deleterious substances that adversely affect the strength and mixing properties of the grout, shall be used to manufacture grout.
- E. Admixtures: Ingredients in the grout other than Portland cement, bentonite, and water that are added to the mixture immediately before or during mixing. Admixtures of softening agents, dispersions, retarders or plugging or bridging agents may be added to the water or the grout to permit efficient use of the materials and proper workability of the grout. However, no admixtures shall be used except as approved by the Engineer.

2.02 EQUIPMENT

The CDSM equipment shall meet the following requirements:

- A. Multi-shaft mixing equipment (machines with at least two overlapping mixing shafts) shall be used for this project; single shaft mixing equipment is not allowed. The mixing shafts shall have mixing augers and blades (paddles) configured in such a manner so that they are capable of thoroughly blending the in situ soils and grout. The power source for driving the mixing shafts shall be sufficient to maintain the required revolutions per minute (RPM) and penetration rate from a stopped position at the maximum depth required.
- B. The CDSM rig shall be equipped with electronic sensors built into the leads to determine vertical alignment in two directions: fore-aft and left-right. The output from the sensors shall be routed to a console that is visible to the operator and the Engineer during penetration.
- C. The CDSM equipment shall be adequately marked to allow the Engineer to confirm the penetration depth to within 6 inches during construction.
- D. As a minimum, the grout shall be premixed in a mixing plant which combines dry materials and water in predetermined proportions. The mixing plant shall consist of a grout mixer, grout agitator, group pump, batching scales, and a computer

control unit. Dry materials shall be stored in silos. Automatic batch scales shall be used to accurately determine mix proportions for water and cement during grout preparation. The dry admixtures, if used for mixing with water and cement, can be delivered to the mixing plant by calibrated auger. However, the Contractor shall prove that the calibrated auger can deliver the quantity of dry admixture with accuracy equivalent to that measured and delivered by weight. Calibration of mixing components shall be done at the beginning of the project and monthly thereafter. The cement shall be adequately protected from moisture and contamination while in transit to and in storage at the job site. Reclaimed cement or cement containing lumps or deleterious matter shall not be used.

- E. Positive displacement pumps shall be used to transfer the grout from the mixing plant to the augers. The grout shall be delivered to each slurry-injecting auger by an individual positive displacement pump.

2.03 GROUT MIX

CDSM Cutoff Walls: The in-place grout mix together with the soils shall achieve (1) a minimum unconfined compressive strength of 60 psi at 28 days, and (2) an average unconfined compressive strength over any continuous 500 linear feet of wall of 80 psi or greater at 28 days, determined as outlined in Paragraph 3.10.B.2 and as defined by ASTM D2166 "Standard Test Method for Unconfined Compressive Strength of Cohesive Soil." In addition, the completed CDSM wall shall achieve a permeability of 1×10^{-6} cm/sec or lower based on the pre-production and production pumping tests. Additional permeability tests done according to ASTM D5804 "Standard Test Method for Measurement of Hydraulic Conductivity of Standard Porous Materials Using a Flexible Wall Perimeter" will be run on core samples from the wall, but these will be for general information only. The acceptance of the CDSM barrier wall for permeability will be determined from the pumping tests. The acceptance of the wall for strength will be based on the unconfined compression tests cut from core samples of the wall.

PART 3 – EXECUTION

3.01 GENERAL

The CDSM walls shall be constructed to the lines, grades, and cross section indicated on the plans. The wall shall consist of overlapping essentially vertical columns, with a diameter of 36 to 40., and shall extend through the on-site soils to the elevations indicated on the plans. The completed wall shall be a homogeneous mixture of grout and the in situ soils. The column overlap needed to achieve a homogeneous wall and meet permeability requirements shall be determined by the Contractor. Mixing is to be controlled by shaft rotational speed, drilled speed, and grout injection rate. Spoils are to be placed in the temporary stockpile after excess liquid has been removed. Fluid material is not to be placed in the stockpile.

3.02 HORIZONTAL ALIGNMENT

- A. The Contactor shall accurately stake the location of the proposed CDSM walls shown on the plans using a licensed surveyor before beginning installation. The columns shall be constructed within six (6) inches of the locations shown on the plans. The Contractor shall provide an adequate method to allow the Engineer to verify the as-built location of the wall during construction.
- B. Movement of the crawler base machine shall provide the preliminary alignment of the augers and the final alignment shall be adjusted hydraulic manipulation of the leads. One stroke of the machine shall construct a CDSM panel consisting of at least two overlapping columns. The wall shall be advanced stepwise by overlapping the adjacent outside columns of the previous strokes.
- C. Following CDSM wall construction, the Contractor shall submit as-built drawings prepared by a licensed surveyor indicating the location of the CDSM walls in terms of project coordinates.

3.03 VERTICAL ALIGNMENT

- A. Vertical alignment of the auger stroke shall be controlled by the equipment operator. Two measures of vertical shall be monitored, the force-aft and left-right. The CDSM columns shall be installed at an inclination deviating no more than 1:80 (horizontal to vertical) from vertical.

3.04 WALL DEPTH

- A. Wall depth shall be determined by the line and grades shown on the plans. The total depth of penetration shall be measured either by observing the length of the mixing shaft inserted or by subtraction of the exposed length of shaft from the total shaft length. The final depth of the stroke shall be noted and recorded on the Daily Quality Control Report by the Contractor. The equipment shall be adequately marked to allow the Engineer to confirm the penetration depth during construction.

3.05 GROUT PREPARATION

- A. Dry material shall be stored in silos and fed to mixers for agitation and shearing. In order to accurately control the mixing ratio of grout, the addition of water and cement shall be determined by weight using the automatic batch scales in the mixing plant. The dry bentonite and admixtures, if used, for mixing with water and cement, may be delivered to the mixing plant by calibrated auger. However, the Contractor shall prove that the calibrated auger can deliver the quality of dry admixture with accuracy equivalent to that measured and delivered by weight.

- B. A minimum mixing time of three minutes and a maximum holding time of three hours will be enforced for the grout. The specific gravity of the grout shall be determined during the design mix program for double checking grout proportions.

3.06 SOIL-GROUT MIXING

- A. The completed wall shall be a uniform mixture of cement or cement-bentonite grout and the in situ soils. Soil and grout shall be mixed together in place by the pugmill-type action of the specially designed overlapping augers and blades on the mixing shafts. The grout shall be pumped through the mixing shafts and injected from the tip of the shafts. The shafts shall break up the soil and blend it with cement grout. The mixing action of the shafts shall be blend, circulate, and knead the soil over the length of the column while mixing it in place with the grout. The quality of the mixing will be evaluated by the Engineer by observing core samples taken by both the Contractor and the Engineer.
- B. Installation of each column shall be continuous without interruption. If an interruption of more than 6 hours occurs, the panel shall be re-mixed for the entire height of the element using the correct dosage of fresh cement grout at no cost or adverse schedule impact to the Project.

3.07 SHAFT ROTATIONAL SPEED AND PENETRATION/WITHDRAWAL RATE

- A. The mixing shaft rotational speed (measure in RPMs) and penetration/withdrawal rates may be adjusted to achieve adequate mixing. The required rotational speeds and penetration/withdrawal rates for the various soil layers encountered shall be determined during the Test Section. The rotational speeds and penetration/withdrawal rates determined during the Test Section shall be used during the balance of the work. If these parameters vary by more than 15 percent from those determined during the Test Section, the Engineer may require additional testing to verify acceptable results at no additional cost to the Owner. The rotational speeds and penetration/withdrawal rates shall be recorded on the Daily Quality Control Report.

3.08 GROUT INJECTION RATE

- A. The grout rate per vertical foot of column shall be in accordance with the requirements of the design mix. The grout injection rate shall be constantly monitored, calculated, and controlled. Additional mixing shall be used when necessary to evenly distributed the grout throughout the entire column to overcome excess or deficient initial grout applications. The volume of the grout injected for each four vertical feet of each column shall be monitored, checked by calculation, and recorded on the Daily Quality Control Report by the Contractor.

3.09 OBSTRUCTIONS

- A. Where unknown obstructions are encountered during the soil-cement stabilization operations, the Contractor shall be prepared to remove the obstruction or encapsulate the obstruction at the direction of the Engineer. If such conditions are encountered, the Contractor shall notify the Engineer in writing by the end of that day, and provide all pertinent information relating to depth, plan location coordinates, expected extent of the obstruction, and proposed methods to overcome the obstruction. Such construction to remove an unanticipated obstruction shall only be performed with the written authorization of the Engineer, and shall be compensated under the respective contract time and materials measurement and payment items approved by the Engineer. The Engineer may delete or relocate certain columns to avoid obstructions.
- B. Three extraction wells have been installed and will be operational at the time of the barrier wall installation. In addition, eight piezometers have been installed. Four of the piezometers will be operational at the time of the barrier wall installation (P-1E, P-2E, P-3E, and P-4E). The piezometers are located approximately 15 feet from the centerline of the new barrier wall. Conduit will be installed to connect the piezometers and extraction wells. This conduit will be marked in the field. It will be the Contractor's responsibility to avoid damage to the wells, piezometers, and conduit and cable. Any damage caused due to construction activities will need to be repaired or replaced at the Contractor's expense.

3.10 QUALITY CONTROL PROGRAM

- A. General
 - 1. The CDSM Quality Control Program shall be the responsibility of the Contractor and shall include, as a minimum, the following components: test cells and pump tests, field monitoring during wall installation, and verification strength and permeability testing. The Contractor shall provide all the personnel and equipment necessary to implement the Quality Control Program. In addition, the Engineer will observe construction on a full-time basis and will review Contractor submittals to check that the Quality Control Program is being properly implemented. Prior to site mobilization, the Contractor shall submit a detailed work plan for the Quality Control Program for review and approval by the Engineer. The work plan shall include, as a minimum, a description of all procedures to be implemented, parameters to be monitored, tolerances for the parameters monitored, and the names of any subcontractors used for testing.
 - 2. Following the TestPre-production test cell and pump test, , the Quality Control Program may be revised, if agreed to by the Engineer. The

established quality control procedures shall be maintained throughout the production wall installation to ensure consistency in the CDSM wall installation and to verify that the work compiles with all requirements indicated in the plans and specifications.

B. Sample Collection and Strength Testing

1. The acceptance of the work will be based on demonstrating that the in-place grout mix together with the soils has achieved the strength and permeability requirements outlined in Paragraph 2.03 herein. The strength and permeability will be determined by testing samples collected by the Contractor. Confirmation sample collection and testing, other than the testing required by the Contractor, may be conducted by the Engineer. Both the Contractor's and the Engineer's testing must demonstrate that the required strengths and permeability are met prior to acceptance of the work. Samples shall be collected using: (1) continuous sampling techniques including continuous core, vibra-core and double tube sampling, and (2) discrete wet or bulk sampling, at frequencies described below.
2. For continuous core, vibra-core and double tube sampling, the sample diameter should be 3 inches or greater. Samples shall be retrieved from locations selected by the Engineer. Sample shall be retrieved using standard coring techniques after the soil-grout mixture has hardened sufficiently and vibra-coring techniques while the soil-grout mixture is wet, or using a double tube sampling technique. The double tube sampler consists of an inner sample tube and an outer sleeve with grease between the sleeve and sampler tube. The two tubes are inserted into the wet soil grout mix and the inner sample tube is retrieved after the mix has hardened sufficiently. The continuous core, vibra-core, and double tube samples shall extend the entire depth of the soil-grout column. For the continuous core method, a minimum recovery of 85 percent for each 3-foot-long segment of the samples shall tentatively be achieved and each 3-foot long segment shall contain four possible test specimens with a length to diameter of at least 2. Final requirements for minimum sample recovery using the continuous core method shall be determined after completion of the test section. Samples retrieved prior to 28-day strength testing shall be stored as required for wet sampling. For each core location, four samples shall be submitted to an Engineer approved testing laboratory for unconfined compressive strength and permeability testing at the Contractor's expense. Two cylinders will be tested for strength at 28 days and two will be held for future testing. The remainder of the sample recovered shall be submitted to the Engineer for possible inspection and confirmation testing. Additional confirmation testing shall be paid for by the Engineer. All core holes shall be grouted after coring.

3. For wet sampling, the Contractor shall prepare and cure the samples as defined in ASTM D4832, "Standard Test Method for Preparation and Testing of Soil-Cement Slurry Test Cylinders," with the following exceptions. The age at the time of testing shall be 7 and 28 days.. Four test cylinders shall be prepared from each sample of in situ mixed material taken at the locations and depths selected by the Engineer. Each cylinder shall be 3 inches in diameter and 6 inches high. The samples shall be taken using a bailer-type device that allows for complete retrieval of the mixed material without additional mixing or segregation. The retrieved sample may be passed through a ¾ inch sieve prior to cylinder fabrication; no other sieving is allowed. No additional mixing may occur after retrieval of the sample from the ground. Testing shall be conducted using ASTM D2166 test procedures by an Engineer approved testing laboratory at the Contractor's expense. A minimum of 1/3 cubic foot of material shall be obtained for preparation of the four cylinders. For each sampling location, two cylinders shall be retained for possible inspection and testing by the Engineer. Additional confirmation testing shall be paid for by the Engineer.
4. If the design strength and permeability indicate in these Specifications are not achieved, the section of the CDSM wall will be rejected; the section limits will be determined by the Engineer. If tests fail to meet the strength and permeability requirements, the Engineer reserves the right to require additional sampling and testing at the Contractor's expense. For failed section, the Contractor will be given the opportunity to remix and retest the failed section at the Contractor's expense.

C. Pre-Production Test Cell

1. At the beginning of the work and prior to production wall installation, the Contractor shall construct a closed cell barrier, full depth, using a portion of the production wall for one side at a location designated by the Owner. The closed cell shall contain an area of at least 500 square feet. Construction of the cell shall be by the same methods as those used for the final barrier wall and those methods shall be fully and accurately described in an as-built report. An as-built drawing shall also be submitted showing the cell and each primary and secondary element accurately in plan and elevation.
2. At the center of the test cell a dewatering well extending at least 30 ft into the sand aquifer shall be installed and developed before the cell is closed. One piezometer shall be installed as shown in the plans 10 ft outside of the wall of the cell at a location approved by the Owner. See drawings for additional details.
3. A pumping test shall then be performed for a duration of 3 days or until the groundwater level inside of the cell has been lowered to a level 30 ft

- below the pre-pumping level, whichever occurs first as noted in the test well. Flow from the well and water levels in the test well and piezometer outside the test cell shall be monitored during the test at the following approximate elapsed pumping times: 1, 2, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, and 55 minutes, 1, 2, 4, 8, and 24 hours, then daily thereafter. The flow shall be measured at the same elapsed pumping times using a new or factory-calibrated flow meter with totalizing and instantaneous flow indication with an accuracy within 1% of the actual flow. All water levels shall be measured with an automatic data recorder at intervals on 30 sec or less. All depth measurements shall be recorded to the nearest 0.01-ft. The well shall be pumped at a rate that ensures that the pump does not break suction within the first 24 hours of pumping. Water levels shall also be recorded 12 hours before pumping begins and then at the same time interval listed above for a duration of 3 days after the pump is shut off.
4. When the specified test drawdown level has been reached, as measured in the test well, the pumping shall be stopped and recovery readings shall be made in the test well and piezometer outside the test cell on the same schedule as the readings after the start of pumping except that the zero time shall be the time that pumping was stopped.
 5. The drawdown data shall be plotted versus elapsed time for both pumping and recovery and submitted to the Owner, along with the records of the flow. The groundwater elevations (Ft, NGVD) at zero drawdown shall be indicated on the plots.
 6. Mississippi River stage data at the Market Street gage shall be plotted (elevation in ft, NGVD vs. date/time) for the period beginning 7 days before the test through at least the final recovery reading. These data can be obtained at <http://mvs-wc.mvs.usace.army.mil/gages.html#miss>. Alternatively, river stage data from the American Bottoms gage may be plotted for the same period.
 7. The data will be analyzed by the Owner to compute the flow into the cell for various time intervals assuming 0.15 for the specific yield of the sand formation within the cell. This assumption will be checked and modified, if appropriate, based on the storage coefficient calculated from drawdown and recovery data. The test section will be considered acceptable if the analysis of the recovery data indicates that the maximum average hydraulic conductivity of the barrier is equal to or less than 1×10^{-6} cm/sec.
 8. If the analysis shows that the hydraulic conductivity of the barrier exceeds the specified value, the contractor shall propose revisions to his installation procedures to achieve the required maximum permeability value and shall install and test another closed cell to demonstrate the

effectiveness of the proposed revised procedure, all at no additional cost to the Owner.

9. The pre-production test cell shall be installed within the CDSM production walls at a location shown on the drawings. The cement and bentonite dosage used for the approved pre-production test cell will be required for use in the production wall construction. If procedures or equipment are changed following the test section, the Engineer reserves the right to request a new test cell at the Contractor's expense.
 10. The Contractor shall obtain samples from the test cell and submit them to an approved laboratory for strength and permeability testing and to the Engineer pursuant to the requirements list above. For each test cell, a minimum of three continuous cores, or vibro-cores, or double tube cores shall be collected from the entire column length at locations selected by the Engineer. Unconfined compression tests will be run on 9 cylinders cut from the cores at 28 days. Permeability tests will be run on 3 samples cut from the cores at 28 days. In addition, wet or bulk samples shall be obtained from at least 10 percent of the cell columns at depths determined by the Engineer. The Contractor may propose other sampling techniques to obtain continuous samples of the CDSM columns which if approved by the Engineer could be substituted either for coring, vibra-coring, or double tube samplings. Unconfined compression tests shall be run on 3 sets of cylinders from bulk samples at 7 and 14, and 28 days. One cylinder from each set will be held for future testing if needed. At least one set of cylinders will be provided to the Engineer for testing.
- D. Production Test Cells and Pump Tests: During production wall installation, two additional test cells shall be installed and tested as noted in section 3.10D at locations shown on the plans. Test data will be analyzed by the Owner as noted in 3.10D. If the analysis shows that the hydraulic conductivity of the barrier exceeds the specified value, the contractor shall propose revisions to his installation procedures to achieve the required maximum permeability value and shall install and test another closed cell to demonstrate the effectiveness of the proposed revised procedure, all at no additional cost to the Owner.
- E. The Contractor shall obtain samples from the production test cells and submit them to an approved laboratory for strength and permeability testing and to the Engineer pursuant to the requirements list above. For each test cell, one continuous core, or vibro-core, or double tube core shall be collected from the entire column length at a location selected by the Engineer. Unconfined compression tests shall be run on 3 cylinders cut from the core at 28 days. Permeability tests will be run on 3 samples cut from the core at 28 days. Three core samples shall be given to the Engineer.

F. Production Wall Construction

1. The production CDSM wall shall be constructed using the sample procedures and equipment that was used for the Pre-production Test Cell. If procedures and/or equipment used for the Pre-production Test Cell are changed, the Engineer reserves the right to request a new test cell, sampling, and the testing at the expense of the Contractor.
2. The Contractor shall obtain samples from the production CDSM wall construction and submit them to an Engineer approved laboratory for strength and permeability testing and to the Engineer pursuant to the requirements listed in Paragraph 3.10B herein. For the production CDSM wall construction, the following minimum testing frequency shall be instituted: Collect one continuous core, vibra-core, or double tube sample extending the full depth of the wall for every (*horizontal*) 500 lineal feet of columns installed. The selection of the required sampling technique shall be determined by the Engineer during construction. Perform unconfined compression tests cut from the cores on at least 6 samples and permeability on 3 samples at 28 days. Provide the Engineer with at least 3 samples.

G. Daily Quality Control Report

1. Day, month, year, time of work shifts (beginning and end); list of all workers names associated with each soil-cement auger mixing rig and grout plant in operation.
2. The location of each completed soil-cement column installed during the work shifts and all soil-cement columns completed to-date on a plan of suitable scale not smaller than 1 inch = 5 feet to clearly show the location of the columns.
3. Time and date of beginning and completion of each soil-cement column installed during the current work shifts.
4. Other pertinent observations including, but not limited to: cement grout escapes; ground settlement and/or heave; collapses of the soil-cement column; and any unusual behavior of any equipment during the soil-cement process.
5. Summary of any downtime or other unproductive time, including time, duration, and reason.
6. Certificate for each truck load delivery of cement and bentonite.

7. Quantity of cement and bentonite and other materials used during installation of wall panels.
8. The Daily Quality Control Reports shall document the progress on the CDSM wall construction. Additionally, the following parameters should be recorded either automatically or manually at every 4 foot interval and the data submitted in the form of either tables or figures (as agreed to by the Engineer) attached to the Daily Quality Control Report:
 - (a) Shaft rotation speed vs. depth
 - (b) Penetration and withdrawal rates vs. depth
 - (c) Grout injection rate of "each" auger vs. depth
9. All strength test results shall be submitted with the Daily Quality Control Reports; sections of the CDSM will not be accepted by the Engineer until at least one working day following receipt of the applicable Daily Quality Control Report and laboratory test results.
10. The Contractor shall submit Daily Quality Control Reports at the end of the next working day. Quality control monitoring during CDSM wall installation shall at a minimum include continuous monitoring of mixing shaft rotational speed vs. real time, and grout injection rate vs. real time.

END OF SECTION

SECTION 02320

CONSTRUCTION SPOILS HANDLING

PART 1 GENERAL

1.1 SUMMARY

- A. This section describes **general earthwork** requirements for construction of the temporary stockpile, soil cover and related activities. This section also includes spoils handling and placement, and daily cover.
- B. This Section does not include the interim cover material. This is covered in Section 02325 – Geomembrane.

1.2 REFERENCES

- A. ASTM C136 - Method for Sieve Analysis of Fine and Coarse Aggregates.
- B. ASTM D698 - Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³).
- C. ASTM D2216 - Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures.
- D. ASTM D2487 - Classification of Soils for Engineering Purposes.
- E. ASTM D2922 - Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
- F. ASTM D2937 - Test Method for Density of Soil in Place by the Drive Cylinder Method.
- G. ASTM D3017 - Test Method for Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
- H. ASTM D4318 - Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
- I. ASTM D1140 - Test Method for Amount of Material in Soils Finer than the No. 200 Sieve.

1.3 DEFINITIONS

- A. **Well-Graded:** A mixture of particle sizes that has no specific concentration, or lack thereof, of one or more sizes. A material type that, when compacted, produces a strong and relatively incompressible soil mass.
- B. **Coverage:** One coverage is defined as the requirement of successive trips of a piece of compaction equipment, which by means of sufficient overlap, will ensure that all areas of the layer being compacted have been subjected to one pass of the compaction equipment.
- C. **Optimum Moisture Content:** The maximum moisture content that will result when plotted against the dry unit weight of a soil when subjected to the ASTM D698 compaction test.
- D. **Percent Compaction:** The percent compaction in-place shall be calculated as the ratio (in percent) of the in-place dry density to the estimated maximum dry density, in accordance with ASTM D698, of the representative fill material at the location of the in-place density test.
- E. **Proof Rolling:** Rolling a surface with a minimum of 3 passes with approved compaction equipment for the purpose of detecting soft or loose areas.
- F. **On-Site Soils:** On-site soils are defined as the insitu material located within the footprint of the liner system and the perimeter berms.
- G. **Borrow Soils:** borrow soils are defined as material transferred to the footprint area from a remote location.
- H. **Unsuitable Materials:** All soil materials that contain waste, debris, roots, organic matter, frozen matter, stone or rock with any dimension greater than 1-inch, or any other material that are determined by the Owner to be unsuitable for stable, compacted backfill purposes. Approved on-site borrow soils are suitable fill.
- I. **Borrow Areas:** Borrow areas are those locations approved by the Owner for procurement, excavation and use of materials for construction of the temporary spoil stockpile. Borrow areas do not include "on-site soils" as defined herein.
- J. **Fine-Grained Soils:** Fined grained soils are defined as those materials which pass a 200 sieve in accordance with the guidelines established in ASTM C136.

1.4 TESTING

- A. The Contractor shall retain the services of a QC testing laboratory that has been approved by the Owner to perform tests as specified herein. At a minimum, the Contractor shall be responsible for providing QC for the following:
 - 1. Compliance testing for materials provided from onsite and offsite sources.
 - 2. QC testing and inspection during construction.
- B. The Contractor shall inspect and verify all earthwork operations are in conformance with this specification and the contract documents. Moisture/density relationships for the various fill materials will be established as part of the QC program. Field density tests, sample selection, and construction observations will be performed in sufficient numbers and in such locations to verify that the specified density is being achieved.
- C. The Contractor shall inform the Owner prior to conducting all field tests to allow oversight. No additional fill placement shall be permitted in areas that have not met the specified fill placement criteria.
- D. No testing of spoils placement is required.

1.5 SUBMITTALS

A. Construction Plan

The Contractor shall submit a construction plan identifying the procedures and methods to be used. The plan shall be approved by the Owner prior to any earthwork activities. The construction plan shall, at a minimum, include the following:

- 1. Proposed material source(s) and proposed method(s) of sampling.
- 2. Proposed soil processing, placement, compaction, and moisture control equipment, including equipment catalog with weight, dimensions, and operating data for all equipment.
- 3. Proposed locations of soil processing and moisture control.
- 4. Proposed methods for soil processing and moisture control.
- 5. Proposed work schedule.
- 6. Proposed method of protecting Work, to include temporary drainage measures.

7. Proposed QC Personnel. All QC personnel shall demonstrate specific experience of at least 2 years in the areas in which they will be performing QC inspections.
 8. Proposed professional engineer registered in Illinois with no less than 5 years experience in the performance and evaluation of geotechnical laboratory tests on constructed materials.
 9. Proposed land surveyor licensed in the State of Illinois.
 10. Proposed excavation, stockpiling, regrading and staging plan describing handling and transport of borrow materials.
- B. Contractor shall submit manufacturer's data and samples of daily cover material.
- C. Contractor shall submit results of prequalification test data on each material source to the Owner for approval prior to procurement, excavation, transport, stockpiling or use.
- D. Contractor shall submit results of all field and laboratory prequalification and quality control data to the Owner within 1 work day of receipt.
- E. Contractor shall submit the results of all observations and documentation generated by its quality control personnel the next work day.
- F. Contractor shall submit results of all field surveys and documentation to the Owner. Copies of surveyor field data, books and notes shall be submitted within 1 work day of generation. Copies of survey information signed and sealed by an Illinois licensed surveyor shall be submitted within 1 work day of receipt.

1.6 PROTECTION

- A. All streets, roads, grading, structures, utilities and other improvements not specifically designated to be cleared, removed, stripped or altered as a part of the work shall be protected from damage throughout the construction period. Any damage caused by the Contractor, his employees, agents, or any lower tiered subcontractors shall be immediately repaired to the original condition and to the satisfaction of the Owner at no additional cost to the Owner.
- B. Traffic Control
1. Keep all roads, sidewalks, and parking areas that are not part of this project usable at all times.

2. The Contractor shall **provide** all necessary barricades, lights, signs, signals, etc., for the protection of **the** workers and the public, as established by the Occupational Safety and Health Administration (OSHA) Construction Safety and Health Regulation 29 CFR, Part 1926, Subpart G, Signs, Signals and Barricades, and in Subpart P- Excavations, trenching and shoring, and IDOT Standard Specifications for Highway Construction, latest edition.

C. Existing Utilities

1. The Contractor is **solely** responsible for identification of all utilities, both known and unknown.
2. Any existing utility **that is** damaged by the Contractor shall be immediately repaired to its previous **undamaged** condition at no additional cost to the Owner.
2. Notify the Owner **immediately** of any encountered utilities not shown on the Drawings.
- 3 Obtain approval from **the** Owner before backfilling in areas of known utilities.

D. Monitoring Wells

1. Contractor shall be **solely** responsible for identification of all groundwater monitoring wells.
2. Known groundwater monitoring wells are indicated on the Plans. Contractor shall not operate **machinery**, excavate, mound soil or otherwise disturb the ground surface around a monitoring well without the concurrence of the Owner.
3. Contractor shall be **solely** responsible for the protection and usability of the monitoring wells **during the work**.
4. If the Contractor **damages a** monitoring well during the performance of the work, the Contractor shall **immediately** notify the Owner of the damage.
5. If the Owner **subsequently** determines that the damaged monitoring well no longer performs **satisfactorily**, the Owner will have the well repaired, replaced or abandoned by a **qualified** well installer and will recover any resulting cost from the Contractor.

PART 2 PRODUCTS

2.1 ON-SITE SOILS

- A. Soils in the vicinity of the stockpile contain a limited amount of organic and inorganic constituents. Excavation and removal of onsite or surrounding soils is not permitted unless approved by the Owner.

2.2 BORROW SOURCES

- A. Borrow sources do not exist within the property boundary of the proposed site for use on this project.
- B. Offsite Sources
 - 1. Contractor shall be responsible for locating sources of borrow material from offsite sources sufficient to construct the perimeter berms and cover for the temporary stockpile. The Contractor shall obtain representative samples of the proposed source for laboratory testing. Results of the testing along with representative samples of the proposed material shall be submitted to the Owner for approval prior to procurement, excavation, transport stockpiling or use.
 - 2. Use of other borrow sources shall only be with the written approval of the Owner. Unless otherwise directed by the Owner all material shall conform to the requirements of the Specifications.
 - 3. Contractor shall be responsible for conducting TCL/TAL testing of borrow soils in accordance with the latest IEPA requirements. Off-site borrow shall be tested at a rate of one sample per 5,000 cubic yards of material excavated. Contractor shall compare the test results with TACO Tier I criteria for commercial / industrial area soils. The test results and the comparison to TACO criteria shall be submitted to the Owner for review and approval. Any borrow soils containing TCL/TAL contaminants above the Tier I levels shall not be acceptable for stockpile construction.

2.3 CLEAN SOIL

A. Compacted Fill

1. Compacted Fill shall consist of random cohesive materials obtained from approved off-site borrow areas. Compacted Fill shall be free of lenses, pockets or layers of material differing in texture, gradation, and moisture from surrounding material. Compacted Fill shall consist of soil types meeting the following classifications of ASTM D2487:

For 4" leveling layer or 12" stockpile cover soil:

Silty to Clayey Sands	SC, SP-SM, SC-SM
Clayey Silts to Silty Clays	CL
Silty Sandy Clays	CL
Combinations of the above	

For berms:

Clayey Silts to Silty Clays	CL
Silty Sandy Clays	CL
Gravelly clay	CL
Combinations of the above	

The plasticity index shall be 7 or greater.

2. The maximum clod size for Compacted Fill shall be 2 inches in any dimension. Oversize material shall be removed or reworked to conform to these requirements. Non-uniform material shall be removed or reworked to conform to these requirements.
3. Fill material placed in the cover that will be in contact with the Geomembrane liner shall not have any particle size greater than 1". Requirements for fill preparation for the cover are addressed in paragraph 3.5 below and Section 02325 Geomembrane.

2.4 EQUIPMENT

- A. All equipment and tools used in the performance of this work are subject to the approval of the Owner before work is started.
- B. Contractor shall provide compaction equipment appropriate for the material types to obtain the densities specified.
- C. Contractor shall provide hand-operated compaction equipment in areas closer than 2 ft from pipes or other structures to obtain the densities specified.

- D. Contractor shall operate and maintain compaction equipment in accordance with the manufacturer's instructions and recommendations. If inadequate densities are obtained, provide larger and/or different type equipment at no added cost to the Owner.
- E. Contractor shall provide equipment for applying water of a type and quality adequate for the Work, free of leaks and equipped with a distributor bar or other approved device to ensure uniform application.
- F. Contractor shall provide equipment for mixing and drying out material, such as blades, discs, or other approved equipment.
- G. Contractors mixing and blending equipment shall fully penetrate loose lifts during mixing to achieve a uniform material.
- H. Contractor shall provide steel drum rollers to prepare the surface of placed or compacted fill prior to placement of geosynthetic materials.

2.5 SPOILS

- A. Spoils are the excess material generated by the construction of the barrier wall, materials excavated for the installation of the effluent pipeline and other materials generated that cannot be used as backfill in other areas of the project.
- B. Spoils do not include materials that contain waste, debris, roots, organic matter, or any other material that are determined by the Owner to be unsuitable.

2.6 DAILY COVER

- A. The cover shall consist of 6 mil thick polyethylene or equal.

2.7 MARKER & FILTER FABRIC

- A. Marker and filter fabric shall consist of 8 oz non-woven polypropylene needle punched geotextile.

2.8 RIP-RAP

- A. Rip-rap shall consist of crushed rock in gradation of 6" to 8" size.

PART 3 EXECUTION

3.1 SURFACE WATER CONTROL

- A. Contractor shall furnish, install, maintain and operate all equipment and materials needed to prevent, control and remove surface water within or adjacent to the area of work in accordance these Specifications.
- B. Contractor shall furnish, install, maintain, and operate all equipment and materials to prevent ground water from flowing into excavations or onto work areas or areas designated to receive fill as necessary or as required by the Owner.

3.2 CLEARING AND GRUBBING – TEMPORARY STOCKPILE

- A. Contractor shall remove vegetation including snags, brush, and rubbish occurring in the areas of the work.
- B. Roots, brush, rotten wood, and other refuse collected by the Contractor from the clearing and grubbing operations shall be disposed by the Contractor at a location designated by the Owner.

3.3 CONSTRUCTION OF TEMPORARY STOCKPILE

- A. General
 - 1. Construct as shown on the plans.
 - 2. Contractor shall construct the soil components of the stockpile and cover system using suitable borrow materials as specified.
 - 3. Contractor shall construct each layer in a continuous and nearly horizontal layer for the full width at the elevation of the layer unless otherwise required by the Specifications or Plans.
 - 4. Contractor shall place and compact all materials to prevent constructed discontinuities in the fill or segregated areas of the work.
 - 5. Special care shall be taken by the Contractor to ensure bonding of new fill to constructed segments previously placed by benching in 2 ft horizontally into the existing fill for each 1-ft vertical placement. This requirement shall not apply to construction interfaces between side slopes and bottom materials.

6. Contractor shall **moisten or aerate**, scarify, and work with harrows, discs, or other suitable equipment in such a manner to reduce the clod size of material being placed to the requirements given. Blend all material to be free from lenses, pockets, or layers of material differing in texture, gradation, and moisture from surrounding materials and to depths that provide a bonding surface with the new material.
7. Soils with excess moisture shall be sufficiently dried to meet the specified compaction requirements.
8. Contractor may at his option add moisture to the borrow area.
9. Soil shall be compacted to a minimum of 90% of the maximum dry density as determined by ASTM D698, at a moisture content +/- 4% of optimum.

3.4 PLACEMENT OF SPOIL

A. General

1. No spoils that exhibit **free moisture** may be placed in its final position within the stockpile. Contractor may construct drying pits to evaporate or remove free water or other liquids prior to placing in the spoil in its final position.
2. Contractor shall place the spoil components within the stockpile using suitable equipment.
3. Contractor shall construct spoil components to the lines and grades shown on the Plans.
4. The spoil material shall be placed by the Contractor in maximum 12-inch thick (loose) lifts.
5. Contractor shall construct each layer of each zone in a continuous and nearly horizontal layer for the full width at the elevation of the layer unless otherwise required by the Specifications or Plans.

B. Compaction of Spoils

1. Prior to placing any new fill, the Contractor shall compact the previous layer upon which new spoil is to be placed. Compaction may be accomplished by running tracked equipment over the spoils until all visible voids are filled.
2. No water may be added to the spoils.

C. Daily Cover

1. At the end of each work day or at any time when the spoils may be left exposed for more than four hours, a cover of polyethylene shall be placed over the spoils to prevent wind or water erosion.
2. The daily cover may be abandoned in place upon resumption of spoil placement.

3.5 PREPARATION FOR INTERIM COVER GEOMEMBRANE PLACEMENT

- A. Contractor shall grade all surfaces and areas to receive geosynthetic materials to achieve a smooth uniform surface, free from sharp edges, ruts or discontinuities.
- B. Contractor shall condition the upper six inches of surface soil in all areas to receive geosynthetic materials with water as necessary to achieve a moisture content of approximately optimum as determined by ASTM D 698.
- C. Contractor shall smooth drum roll all areas after moisture conditioning is complete. Soft or spongy areas of fill shall be removed at the direction of the Owner and replaced in accordance with the requirements of these specifications at no cost to The Owner.
- D. Contractor shall certify to the Owner that all areas to receive geosynthetic materials area free from sharp edges, ruts or discontinuities.
- E. Prior to releasing an area for geosynthetic placement, the Owner will inspect the area for conformance to these specifications. Contractor shall rework areas that that are deemed not acceptable by the Owner until acceptance is achieved.

3.6 MAINTENANCE

- A. During the course of the work and during work interruption(s) Contractor shall be solely responsible for protection of compacted materials.
- B. Contractor shall remove and replace or recondition damaged materials.

3.7 CONSTRUCTION TOLERANCE

- A. Survey Precision

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1. Contractor shall provide survey control for all earthwork placement, compaction, excavation and grading and as otherwise directed by the Owner.
2. Contractor shall perform surveys of the work to ± 0.1 ft vertically and ± 0.25 ft horizontally.

B. Surface Tolerance

1. Contractor shall construct finished subgrades, compacted surfaces and drainage material layers from -0.0 to +0.1 ft.
2. Contractor shall provide constructed work with variations in final grade ≤ 0.25 ft above minimum thickness vertically between any two points located within 100 ft in any direction with the exception of designated changes in grade.

3.8 SURVEY CONTROL DATA

- A. Survey data shall be collected as specified below or as otherwise directed by The Owner.
1. Contractor shall collect survey data at the center of the stockpile beneath the lining system footprint and at the top of the finished stockpile.
 2. Contractor shall collect survey data for the outside toe and top of slope of the finished perimeter berm.

3.9 QUALITY CONTROL

A. General

1. Tests and analysis of fill materials will be performed by the Contractor's approved QC personnel and Testing Laboratory.
2. Field inspection and testing will be performed by the Contractor.
3. The test frequency option which results in the greatest number of tests shall be used by the Contractor.
4. If the Contractor's in-place density test fails due to moisture content or density, re-test in the same area. If the second test fails, remove or rework area defined by surrounding tests meeting the Specifications.

5. All perforations due to density test probe, sample tubes, or test pit excavation shall be backfilled by the Contractor. All perforations shall be backfilled with material similar to that of the layer. Backfill shall be recompacted using methods and procedures specified.
6. One point compaction tests shall be performed by the Contractor whenever a change in material is observed or suspected, as directed by the Owner, and no less than once per day per material type.
7. Contractor may use one point compaction data for calculation of maximum Standard Proctor dry density until a laboratory generated moisture density curve is developed. Contractor may continue placement at his own risk.
8. If placed and compacted material does not meet the requirements of these Specifications based on the laboratory generated moisture density curve, the Contractor shall remove or rework all such material to meet these requirements at no additional cost to the Owner.
9. Contractor shall submit all preconstruction and construction quality control data with a cover letter signed and sealed by a Illinois registered professional engineer indicating the requirements of the Specifications have been achieved and the data as presented is representative of the material tested.

B. Preconstruction Material Quality Evaluation

1. The Contractor shall perform material quality evaluations on all proposed borrow sources for approval by the Owner prior to procurement, excavating, transport, stockpiling or use.
2. Compacted Fill testing requirements:
 - ASTM D 2216 1 per source
 - ASTM D 4318 1 per source
 - ASTM D 1140 1 per source
 - ASTM D 698 1 per source

C. Construction Material Quality Evaluation

1. Laboratory testing shall be performed by the Contractor's QC personnel on each source throughout the performance of construction.
2. Compacted Fill testing requirements for each borrow source used:

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- ASTM D 2216 1 per 15,000 yds³
- ASTM D 4318 1 per 15,000 yds³
- ASTM D 1140 1 per 15,000 yds³
- ASTM D 698 1 per 15,000 yds³

D. Post Constructed Quality Control

1. Compacted Fill

- | | |
|-----------------------------------|---|
| In-place density | 1 per 2,000 yd ³ placed and compacted |
| ASTM D2922 | |
| ASTM D3017 | |
|
In-place density verification |
1 per 15,000 yd ³ placed and compacted |
| ASTM D2937 | |
| ASTM D2216 | |

END OF SECTION

SECTION 02325

GEOMEMBRANE

PART 1 GENERAL

1.1 SUMMARY

- A. The Contractor shall furnish all material, labor and equipment for the installation of the geomembrane interim cover as specified herein and as shown on the Drawings, and shall install the geomembrane and other geosynthetic components of the interim cover system in close coordination with the Owner.

1.2 REFERENCES

- | | | |
|----|----------------------------|---|
| A. | ASTM D 638 - | Test Method for Tensile Properties of Plastics. |
| B. | ASTM D 792 - | Test Method for Specific Gravity (Relative Density) and Density of Plastics by Displacement. |
| C. | ASTM D 1004 - | Test Method for Initial Tear Resistance of Plastic Film and Sheeting. |
| D. | ASTM D 1204 - | Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature. |
| E. | ASTM D 1238, Condition E - | Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer. |
| F. | ASTM D 1505 - | Test Method for Density of Plastics by the Density - Gradient Technique. |
| G. | ASTM D 1603 - | Test Method for Carbon Black in Olefin Plastics. |
| H. | ASTM D 4437 - | Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes. |
| I. | ASTM D 4833 - | Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products. |
| J. | ASTM D 5199 - | Test Method for Measuring Thickness of Plastics. |

- K. ASTM D 5397
- O. ASTM D 5596
- P. ASTM D 3895
- Q. ASTM D 5885
- R. ASTM D 5721
- S. ASTM D 746
- T. ASTM D 5321
- U. NSF 54, Mod.
- V. GM 11
- W. GM12

1.3 DEFINITIONS

- A. **Batch**: A quantity of resin, usually the capacity of one railcar, used in the fabrication of High Density Polyethylene (HDPE) geomembrane rolls. The finished rolls are identified by a roll number corresponding to the resin batch used.
- B. **Bridging**: Condition existing when the geomembrane is not in contact with the underlying material.
- C. **Contractor**: The party responsible for manufacturing, shipping, field handling, transporting, storing, deploying, seaming, temporary restraining (against wind), and installing the geomembrane. This responsibility includes the work performed by the Manufacturer and the Installer.
- D. **Manufacturer**: The party responsible for production of any of the various geosynthetic components.
- E. **Installer**: The part responsible for installation of the geosynthetics.
- F. **Extrudate**: HDPE material produced in the form of a rod used by the Contractor to extrusion weld panels of geomembrane together.
- G. **Geomembrane**: Very-low permeability synthetic flexible membrane liner (FML) barrier used to minimize fluid migration.

- H. Geomembrane Subsurface: Material surface upon which geomembrane will be placed.
- I. Quality Assurance Laboratory (Third Party Laboratory): Party, independent from the Owner, Manufacturer, and Contractor, responsible for conducting laboratory tests on samples of geomembrane obtained at the site.
- J. Panel: The unit area of geomembrane, a roll or a portion of a roll, that will be seamed in the field.
- K. Panel Layout Drawings: Drawings submitted by the Contractor indicating panel numbers, field seams, and details.
- L. Subgrade: Soil material directly below the geomembrane.

1.4 TESTING

- A. Contractor shall retain the services of a geosynthetics testing laboratory. At a minimum, Contractor shall be responsible for providing the following quality control information:
 - 1. Compliance testing for installed geosynthetics.
 - 2. Quality control testing during construction.
- B. The Contractor shall inspect and ensure all work is in conformance with these Specifications.
- C. Contractor shall inform the Owner prior to conducting all quality control testing to allow oversight.
- D. Contractor shall submit all quality control data (both pre-construction and construction) with a cover letter signed and sealed by a Illinois registered professional Owner indicating the requirements of the Specifications were achieved and the data is representative of the material tested.

1.5 SUBMITTALS

- A. General
 - 1. Contractor shall submit qualification information on the Manufacturer, Installer and Geosynthetic Testing Laboratory.

2. Contractor shall submit the results of conformance testing of the geosynthetic materials selected for interface friction testing for approval within thirty (30) days of contract award.
3. Contractor shall submit prequalification data on each geosynthetic material to the Owner for approval prior to procurement transport, stockpiling or use.
4. Contractor shall submit results of all quality control data and information to the Owner within 1 work day of receipt.
5. Contractor shall submit all observations and documentation generated by its quality control personnel daily for the current day's activities.
6. Contractor shall submit results of all field surveys and documentation within 1 day of generation including copies of data, field books and notes. Copies of survey information signed and sealed by a Illinois licensed surveyor shall be submitted written 1 day of receipt.

B. Manufacturer

The Manufacturer shall submit the following prior to installing geosynthetics:

1. A list of material properties including certified test results attached to samples of the proposed geosynthetic material.
2. The origin and identification of the resin used to manufacture the products.
3. Submit all quality control documentation required by these Specifications prior to installation.

C. Installer

The Installer shall submit the following prior to installation:

1. Resume of Superintendent to be assigned to the project including dates/duration of employment.
2. Resume of Master Seamer including dates/duration of employment.
3. A list of personnel to be performing field seaming operations with pertinent experience information.
4. All geosynthetic quality control certificates .

5. Certification that the extrudate is comprised of the same resin as the geomembrane to be used.
 6. Description of seaming techniques and apparatus to be used.
 7. Properties of extrudate to be used.
- D. Raw Materials
1. Copy of quality control certificates issued by resin suppliers.
 2. Production date(s) of resin.
 3. Reports on tests conducted to confirm quality of resin used to manufacture geomembrane rolls assigned to considered facility. Report shall indicate compliance with requirements in Part 2 – Products of this Specification.
 4. Statement that no reclaimed polymer is added to resin during manufacture of actual geomembrane to be used in this project.
- E. Geomembrane Roll Production: Copy of quality control certificates indicating compliance with requirements of Part 2 of this Specification.
- F. Installation Panel Layout Drawing identifying placement patterns and seams, both fabricated (if applicable) and field seams, as well as any variance or additional details which deviate from the Drawings. Layout shall be drawn to scale and shall be adequate for use as the construction plan, and shall include information such as dimensions, panel numbering, and installation details. The Owner will review all Panel Layout Drawings prior to installation.
- G. Installation Schedule.
- H. During installation the Contractor shall submit:
1. Quality control documentation recorded during installation.
 3. Daily subgrade acceptance for each area to be covered signed by the Installer.
- I. Warranties:
1. Submit a material warranty signed by the geomembrane manufacturer. The material warranty shall be against manufacturing defects and workmanship, and against deterioration due to ozone, ultraviolet, and other exposure to the elements, for a period of one year from final acceptance. The material

warranty shall be limited to replacement of material, and shall not cover installation of replacement geomembrane.

2. Submit workmanship warranty signed by the geomembrane installer. The installer shall warrant the geomembrane system to be installed to be free of defects in workmanship for a period of 2 years following the date of final acceptance of the work under this Contract. The workmanship warranty shall cover installation of replacement geomembrane.

J. Submittals Required for Project Closeout

1. Record Drawing: Submit reproducible drawings of record showing changes from the approved installation drawings. The record drawings shall include the identification and location of each repair, cap strip, penetration, boot, and sample taken from the installed geomembrane.
2. Quality Control Record: Submit copies of all material and seam test results. Each test shall be identified by date of sample, date of test, sample location, name of individual who performed the test, and standard test method used.
3. Weld Test Summary Report: Submit copies of report showing normal distribution of all test results, and individual test results identifying the high, low, and average of the five coupon samples in each test.

1.6 QUALIFICATIONS

A. Manufacturer

1. Manufacturer shall have at least 5 years continuous experience in the manufacturing of HDPE geomembrane rolls and experience totaling 2 million sq ft of manufactured HDPE for at least 10 completed facilities.
2. The Manufacturer shall have an internal quality control program that meets standard industry requirements.

B. Installer

1. The Installer shall have at least 5 years continuous experience in the installation of HDPE geomembrane and experience totaling 2 million sq ft of installed HDPE geomembrane for at least 10 completed facilities.
2. The Installer's Superintendent shall have previously managed at least two installation projects which entail at least 100,000 ft² of HDPE geomembrane.

3. Personnel performing seaming operations shall be qualified by experience or by successfully passing seaming tests. At least one "Master Seamer" shall have experience seaming a minimum of 1 million sq. ft. of HDPE geomembrane using same type of seaming apparatus in use on-site. The "Master Seamer" shall have experience seaming textured and non-textured material and shall provide direct supervision, as required, over less experienced seamers.

C. Quality Assurance Plan

Manufacturer/Contractor shall agree to participate in and conform to all items and requirements of these Specifications and the Construction Quality Assurance Plan for the Installation of Geosynthetic Components.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Deliver and store geomembrane in strict accordance with the manufacturer's recommendations.
- B. Geomembrane delivered to the site shall be inspected for damage, unloaded, and stored with a minimum of handling. The storage area shall be such that materials are protected from mud, soil, dirt, and debris. Geomembrane may be stored directly on prepared level surface, but no more than three rolls in height.
- C. The Contractor shall be responsible for coordination and payment of shipping, unloading, storing, handling and installing geomembrane.
- D. Use appropriate handling equipment to load, move or deploy geomembrane rolls. Appropriate handling equipment includes slings, spreader bars or an equipment bucket which has been properly protected.
- E. Damaged or unacceptable materials shall be replaced at no additional cost to the Owner.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. GSE Lining Technology, Inc. (Gundle/SLT), Houston, Texas.
- B. Approved Equal

2.2 GEOMEMBRANE

- A. The geomembrane shall consist of new, first-quality products designed and manufactured specifically for the purpose of this work, as satisfactorily demonstrated by prior use.
- B. The geomembrane shall be high-density polyethylene (HDPE) with a UV-stabilized surface and contain no plasticizers, fillers, chemical additives, reclaimed polymers, or extenders.
- C. Approximately 2 percent carbon black shall be added to the resin for ultraviolet resistance.
- D. The only other compound elements shall be anti-oxidants and heat stabilizers, of which up to 1.5 percent total, as required for manufacturing, may be added.
- E. The geomembrane shall be supplied as a single-ply continuous sheet with no factory seams. Rolls shall have a minimum width of 22 feet.
- F. The roll length shall be maximized to provide the largest manageable sheet for the fewest field seams.
- G. All rolls shall be identified with a unique roll number printed on a label affixed to the inside and outside of the roll.
- H. Each roll shall have a continuous identification printed on the membrane showing manufacturer, thickness, material, and date of manufacture.
- I. HDPE geomembrane shall meet the following requirements:

HDPE GEOMEMBRANE - SMOOTH

Liner Thickness, mils (nominal)	ASTM D5199	60	Per Roll
Density (g/cc)	ASTM D1505-A	0.94	200,00 lbs
Tensile Properties (min. avg.)	ASTM D638 Type IV Dumb-bell @ 2 ipm (2.0" Gauge Length) (NSF 54, Mod.)		20,000 lbs
1. Tensile Strength @ Yield (ppi)		126	
2. Tensile Strength @ Break (ppi)		228	
3. Elongation @ Yield (%)		12	
4. Elongation @ Break (%)		700	
Tear Resistance (min. avg.)	ASTM D1004 Die C	42 lbs	45,000 lbs
Dimensional Stability % Change Each direction	ASTM D1204 212 °F 1 hr	± 2	
Stress Crack Resistance (hrs)	ASTM D5397	200	Per Batch
Puncture Resistance (min. avg.)	ASTM 4833	108 lbs	45,000 lbs
Carbon Black Content (%)	ASTM D1603	2	20,000 lbs
Carbon Black Dispersion	ASTM D5596	A1, A2 and B1	45,000 lbs
Oxidative Induction Time (OIT)			200,000 lbs
(a) Standard OIT (min. avg.) -or-	ASTM D3895	100 minutes	
(b) High Pressure OIT (min. avg.)	ASTM D5885	400 minutes	
Oven Aging at 85°	ASTM D5721 ASTM D3895	55%	Per Batch
(a) Standard OIT (min. avg.) - % retained after 90 days -or-			
(b) High Pressure OIT (min. avg.) - % retained after 90 days	ASTM D5885	80%	
UV Resistance	GM 11 ASTM D3895	Not Recommend	Per Batch
(a) Standard OIT (min. avg.) -or-	ASTM D5885	50%	
(b) High Pressure OIT (min. avg.) - % retained after 1600 hrs			

- J. Geomembrane shall not have striations, roughness, pinholes or bubbles on the surface

2.3 EXTRUDATE

- A. Extrudate shall be made from the same resin as the geomembrane.
- B. Additives shall be thoroughly dispersed in the extrudate.
- C. Additives shall be free of contamination by moisture or foreign matter.

2.4 FIELD SEAMS

- A. Approved processes for seaming are extrusion welding and fusion double seam welding. Fusion double seam welding is the preferred method for joining long, straight seams. Extrusion welding is the preferred seaming method in areas such as corners, sumps, pipe penetrations, tear repairs and cap strips where fusion double seam welding is not feasible.
- B. Only apparatus which has been specifically approved by make and model shall be used.
- C. Proposed alternate processes shall be documented and submitted by the Contractor for approval by the Owner.
- D. Resin used for extrusion welding shall be produced from same resin type as geomembrane.
- E. Physical properties of the welding resin shall be the same as those of the resin used in the geomembrane.
- F. Geomembrane seams shall meet following requirements:

HDPE GEOMEMBRANE SEAM PROPERTIES

Property	Quantity	Unit	Required Value	Test Method
Shear Strength (at yield point)	minimum	lb/in. width	120 and FTB ¹	ASTM D 4437
Peel Adhesion Fusion	minimum	lb/in. width	100 and FTB ¹	ASTM D 4437
Peel Adhesion Extrusion	minimum	lb/in. width	100 and FTB ¹	ASTM D 4437

Note:

¹ = Film Tear Bond (FTB) is defined as failure of one of the sheets by tearing, instead of separating from the other sheet at the weld interface area (i.e., sheet fails before the weld fails).

2.5 EQUIPMENT

A. Welding Equipment:

1. The Contractor shall provide welding equipment equipped with gauges showing temperatures at the nozzle (extrusion welder) or at the wedge (wedge welder), or have the equipment capable of measuring the temperature of the nozzle (hot air).
2. Equipment shall be maintained in adequate number to avoid delaying work, and shall be supplied by a power source capable of providing constant voltage under a combined-line load.
3. Electric generator shall not be placed on the membrane, unless otherwise approved by the Owner.

B. Field Tensiometer:

1. The Contractor shall provide a tensiometer for onsite shear and peel testing of geomembrane seams.
2. The tensiometer shall be motor driven and have jaws capable of traveling at a measured rate of two (2) inches per minute.
3. The tensiometer shall be in good working order, built to ASTM specifications, and accompanied by evidence of recent calibration.

4. It shall be equipped with a gauge that measures the force in unit pounds exerted between the jaws and have a digital readout.

C. Punch Press:

1. The Contractor shall provide a punch press for the onsite preparation of specimens for testing.
2. The press shall be capable of cutting specimens in accordance with ASTM D4437.

D. Vacuum Box:

1. The Contractor shall provide a vacuum box for onsite testing of geomembrane seams.
2. The vacuum box shall have a transparent viewing window on top and a soft, closed-cell neoprene gasket attached to the bottom.
3. The housing shall be rigid and equipped with a bleed valve and vacuum gauge.
4. A separate vacuum source shall be connected to the vacuum box.
5. The equipment shall be capable of inducing and holding a vacuum of 5 psi.

E. Air Pressure Testing (for double seam with an enclosed space):

1. The equipment shall consist of a manual or motor driven air pump equipped with a pressure gauge.
2. The equipped shall be capable of generating and sustaining pressure over 25 psi.
3. Equipment shall be mounted on a cushion to protect the geomembrane.
4. It shall be equipped with a rubber hose with fittings and connections along with a sharp hollow needle.
5. Other pressure feed devices with a gauge and an accuracy of one (1) psi may be used, as approved by the Owner.

PART 3 EXECUTION

3.1 SURFACE CONDITIONS

- A. Additional requirements for preparation of the leveling soil which will become the subgrade are covered in paragraph 3.5 of Section 02320, Temporary Spoils Stockpile.
- B. Contractor shall remove all gravel and other protrusions from geomembrane subgrade. Grade stakes or hubs shall also be removed from subgrade prior to geomembrane placement.
- C. Special care must be taken to maintain prepared soil surface. Soil surface shall be observed daily to evaluate desiccation cracking. Damage to subgrade shall be repaired to the satisfaction of the Owner.
- D. Do not place geomembrane in area which has become softened by precipitation.
- E. Contractor shall certify to the Owner in writing daily that the surface on which the geomembrane will be placed is acceptable.

3.2 PREPARATIONS

- A. Damage to geomembrane subsurface during geomembrane deployment or other activities shall be repaired prior to installation.
- B. Subgrade shall be smooth and consist of clean fine graded material free of rocks, protrusions, sharp objects and deleterious material of any kind.
- C. Edges of excavations and grade changes should be rounded to a minimum six (6) inch radius.
- D. Geomembrane material may be placed when air temperature is greater than 35°F, and increasing or less than 100°F, unless other limits are approved, in writing, by The Owner.
- E. Do not place during precipitation in presence of excessive moisture (e.g., fog, dew), in area of ponded water, or during excessive winds.

3.3 ANCHOR TRENCH

- A. The anchor trench shall be excavated by the Contractor to the lines and grades shown on the Plans prior to geomembrane deployment.
- B. Contractor shall remove all loose soil from the anchor trench prior to geomembrane deployment. No loose soil shall be allowed to underlie the geomembrane.

- C. Excavated surface of the anchor trench shall be protected by the Contractor from desiccation or excessive moisture.
- D. Contractor shall not damage geomembrane during backfill placement in anchor trench.

3.4 DEPLOYMENT

- A. Each panel deployed shall be assigned a simple and logical identifying code consistent with the submitted panel layout drawings.
- B. No more panels shall be deployed in one day that can be welded during that same day.
- C. Tack welding may be acceptable as a temporary measure; however, tack welded panels shall not be left overnight.
- D. Panels shall be shingled on all slopes such that the upper panel of a cross-seam is overlapped above the lower panel.
- E. Panels shall be oriented perpendicular to the line of the slope crest (i.e., down and not across slope) anchored securely and deployed down the slope in a controlled manner. Panels shall not be pulled up the slope.
- F. Ballast, that will not damage the geomembrane, shall be used to prevent uplift due to wind. Methods used shall minimize wrinkles.
- G. Contractor shall securely anchor the geomembrane on a daily basis to prevent "pull-out" from the anchor trench with materials and methods approved by the Owner. Special attention should be given to geomembrane shrinkage overnight.
- H. Folds shall be immediately removed on all installations.
- I. Personnel walking on the geomembrane shall not engage in activities or wear types of shoes, that could damage the geomembrane.
- J. Smoking shall not be permitted while working on the geomembrane.
- K. Vehicular traffic directly on the geomembrane shall not be permitted.
- L. Equipment shall not damage the geomembrane by handling, trafficking, leakage of hydrocarbons, or any other means.

- M. The geomembrane surface shall not be used as a work area, for preparing patches, storing tools and supplies, or other uses. If needed, a protective cover may be spread out as a work surface.
- N. Material shall be placed in a manner to allow for geomembrane shrinkage, contraction and to avoid bridging.

3.5 SEAMING

A. Seam Layout

1. In general, orient end seams (traverse) parallel to line of maximum slope, i.e., oriented along, not across, slope. In corners and odd-shaped geometric locations, minimize numbers of field seams.
2. Seam coding system shall be compatible with panel coding system.
3. During welding operations, at least one Master Seamer shall be present and shall provide supervision over other welders.
4. The surface of the geomembrane shall be clean of grease, moisture, dust, dirt, debris, or other foreign material.
5. Solvents or adhesives shall not be used unless the product is approved in writing by the Owner.
6. Panels shall overlap by a minimum of four (4) inches for all welds.
7. Seams shall be welded to the outside edge of panels placed under anchor berms or in anchor trenches.
8. Fishmouths or wrinkles at seam overlaps shall be cut to achieve a flat overlap.
9. The cut fishmouths or wrinkles shall be extrusion welded or patched where the overlap is more than three (3) inches.
10. When there is less than three (3) inches overlap, an oval or round patch extending a minimum of six (6) inches beyond the cut in each direction shall be used.
11. Seams shall be welded only when ambient temperature is between 35°F and 100°F as measured 6 inches above the geomembrane surface unless other limits are approved in writing by the Owner.

B. Extrusion Seaming

1. Adjacent panels shall be tack bonded together using procedures that do not damage the geomembrane, allow required tests to be performed, and are not detrimental to final seaming.
2. Welding apparatus shall be free of heat-degraded extrudate before welding.
3. The geomembrane surface shall be abraded a maximum of 1/4 inch beyond the weld bead area, using a disc grinder, or equivalent, not more than one hour before extruding seam.
4. The ends of all seams, which are more than five (5) minutes old, shall be ground when restarting the weld.
5. Grinding depth shall not exceed ten (10) percent of the liner thickness.
6. Use apparatus equipped with gauges giving temperature in apparatus and at nozzle.
7. Provide documentation of extrudate to the Owner and certify that extrudate is compatible with specifications and is comprised of same resins as geomembrane.
8. Maintain one spare operable seaming apparatus on-site. Equipment used for seaming shall not damage geomembrane. Protect geomembrane from damage in heavily trafficked areas.
9. Purge extruder prior to beginning seam until all heat-degraded extrudate has been removed from barrel.
10. Place electric generator on smooth base. Place smooth insulating plate or fabric beneath hot welding apparatus after use.

C. Fusion Seaming

1. Welding apparatus shall be automated, vehicular-mounted, and equipped with gauges indicating applicable temperatures and pressures.
2. Edges of cross seams shall be ground smooth including top and bottom prior to welding.
3. Maintain one spare operable seaming apparatus on-site. Equipment used for seaming shall not damage geomembrane. Protect geomembrane from damage in heavily trafficked areas.

D. Trial Welds

1. Trial welds shall be performed on geomembrane samples to verify welding equipment operations and performance of seaming methods and conditions.
2. Minimum of two (2) trial welds per day or shift per welding apparatus shall be made, one made prior to the start of work and one completed at mid shift.
3. Welds shall be made under the same surface and environmental conditions as the production welds (i.e., in contact with geomembrane subsurface and similar ambient temperature).

E. Trial Weld Testing

1. Sample shall be at least three (3) feet long and two (2) feet wide with the seam centered lengthwise.
2. Three (3), 1-inch wide test strips shall be cut from the trial weld.
3. Each of the specimens shall be tested in the field by the Contractor for peel and shear using a digital tensiometer.
4. Remaining sample shall be retained for future testing.
5. A trial weld specimen shall pass when the results are achieved for both peel and shear tests as shown herein. For double-wedge welding, both welds shall be individually tested and both shall be required to pass in peel.
6. Seaming apparatus or seamer shall not be accepted and shall not be used for seaming until deficiencies are corrected and two consecutive successful full trial seams are achieved

3.6 MATERIAL QUALITY EVALUATION

- A. Contractor shall submit an affidavit and/or quality control certificate signed by the geomembrane manufacturer certifying that the geomembrane blankets and/or rolls meet or exceed specified requirements to the Owner for approval prior to geomembrane deployment.
- B. Preinstallation material quality evaluation testing shall be performed as follows:

1. Raw material for geomembrane and extrudate rod or bead:

- ASTM D792 1 per batch
- ASTM D1238, Condition E 1 per batch
- ASTM D746 1 per batch

2. Geomembrane Roll:

- ASTM D5199 Continuous or 25 per sheet
- ASTM D638 1 per 50,000 ft²
- ASTM D1505-A 1 per 50,000 ft²
- ASTM D1004, Die C 1 per 50,000 ft²
- ASTM D4833 1 per 50,000 ft²
- ASTM D1603 1 per 100,000 ft²

C. Conformance Testing

1. Samples shall be obtained at a frequency of one sample per 50,000 square feet.
2. The Contractor shall obtain samples and forward them to a laboratory designated by the Owner.
3. Tests shall be performed to determine geomembrane Density (ASTM D1505), Thickness (ASTM D5199) and Tensile Strength (ASTM D 638).
4. The sample shall be across the entire width of the roll excluding the first three (3) feet, and shall be cut three (3) feet long by width of roll.
5. Within 30 days of contract award, Contractor shall submit the results of the following interface shear tests:
 - Smooth HDPE - Compacted Soil
 - Smooth HDPE - Geonet
 - Textured HDPE - Geonet
 - Textured HDPE - Geosynthetic Clay Liner

These tests shall be performed in accordance with ASTM D 5321.

3.7 CONSTRUCTION QUALITY EVALUATION

- A. Contractor shall non-destructively test all field seams over their full length using a vacuum test unit, air pressure (for double fusion seams only), or other approved

methods. Non-destructive testing shall be carried out daily as the seaming progresses and not at completion of all seaming or at the completion of the day.

B. Vacuum testing shall conform to the following requirements:

1. The equipment shall consist of 2 vacuum box assemblies consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, a port hole or valve assembly, a vacuum gauge, a vacuum pump assembly equipped with a pressure control, a rubber pressure/vacuum hose with fittings and connections, a soapy solution and an applicator.
2. Testing shall conform to the following procedure: Brush soapy solution on geomembrane (approximately 12" x 36"). Place vacuum box over the wetted seam area. Close bleed valve and open vacuum valve, and ensure that a leak-tight seal is created. Apply a vacuum of approximately five (5) psi. Examine the geomembrane through the viewing window for the presence of soap bubbles for not less than fifteen (15) seconds. All areas where soap bubbles appear shall be marked and repaired as described in this Section. If no bubble(s) appear after 15 seconds, close vacuum valve and open bleed valve, move box over next adjoining area with minimum three (3) inches overlap, and repeat process.

C. Air Pressure Testing (for double seam with an enclosed space):

1. The equipment shall consist of an air pump (manual or motor driven) equipped with a pressure gauge capable of generating and sustaining pressure over twenty-five (25) psi and mounted on a cushion to protect the geomembrane, a rubber hose with fittings and connections, a sharp hollow needle, or other approved pressure feed device, and a gauge with an accuracy of one (1) psi.
2. Testing shall conform to the following procedure: Seal both ends of the seam to be tested. Insert needle or other approved pressure-feed device into the channel created by the double-wedge weld. Energize the air pump to a minimum pressure of twenty-five (25) psi, close the valve, and sustain the pressure for at least five (5) minutes. If pressure loss exceeds two (2) psi or does not stabilize, locate faulty area and repair as described in this Section. Puncture opposite end of the seam to release air. If blockage is present, locate and test seam on both sides of blockage. Remove needle or other approved pressure-feed device and seal penetration holes by extrusion welding.

D. Spark Testing: For those extrusion welded seams which are unable to be tested by a vacuum box, the spark test method shall be used with a 24-gauge copper wire placed 1/8" under the top sheet overlap and a Holiday detector operating at 20,000 volts.

- E. Field seam locations that cannot be non-destructively tested by the Contractor as determined by the Owner will be cap-stripped using the same materials as the underlying geomembrane.

3.8 DESTRUCTIVE TESTING

A. Sample Location

1. Collect destructive test samples at a minimum frequency of one test per 1,000 feet of seam length or more frequent as directed by the Owner. Test locations shall be determined during seaming. Locations may be prompted by appearance of excess heating, contamination, offset welds, or suspected defect. The Owner will be responsible for choosing the locations. The Owner will not notify the Contractor in advance of selecting locations where seam samples will be taken.
2. The Contractor shall cut samples at locations designated by the Owner as the seaming progresses to obtain laboratory test results before the geomembrane is covered. The Owner will number each sample and mark the sample number and location on the panel layout drawing.
3. The Contractor shall immediately repair all holes in the geomembrane resulting from destructive sampling. The continuity of the repair shall be vacuum tested in accordance with this Section.
4. The destructive sample shall be eighteen (18) inches wide by forty-two (42) inches long with the seam centered lengthwise. The sample shall be cut into three (3) equal parts for distribution to the Contractor, the Laboratory and the Owner for archiving.

B. Laboratory Testing

1. Samples shall be tested in peel and shear (ASTM D4437).
2. All tests shall exhibit a Film Tearing Bond type of separation in which the geomembrane material tears before the weld.
3. At least five (5) coupons shall be tested by each test method.
4. Four (4) of the five (5) coupons shall meet the minimum requirements stated herein.
5. Test results shall be provided verbally within 24 hours after receiving samples, and within three (3) days in written form.

C. Destructive Test Failure

1. One of two options shall be followed:

- a. **Option 1:** Reconstruct the seam between any two (2) passed test locations.
- b. **Option 2:** Trace the weld to an intermediate location at least ten (10) feet minimum or to where the seam ends, in both directions from the location of the failed test to collect a destructive test sample at both locations. Check the next seam welded using the same welding device if required to obtain an additional sample (i.e., if one side of the seam is less than ten (10) feet long). Bounding laboratory samples shall be taken, and destructive testing shall be performed per this Section. If the bounding samples pass, then the seam shall be reconstructed between the test sample locations. If any additional samples fail, then the process shall be repeated to establish the zone in which the seam shall be reconstructed.

2. Reconstruction methods shall include extrusion welding of previously wedge welded seams, cap stripping of seam, or replacing seam with a new one (1) foot wide panel and welding in place.

- D. Acceptable seams shall be bounded by two locations from which samples have passed destructive tests. For reconstructed seams exceeding fifty (50) feet, a sample taken from within the reconstructed seam shall also pass destructive testing. Whenever a sample fails, additional testing may be required for seams that were welded by the same welder and welding apparatus or were welded during the same shift.**

3.9 DEFECTS AND REPAIRS

- A. The geomembrane shall be examined for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter.
- B. The geomembrane surface shall be clean at the time of the examination.
- C. Each suspect location shall be repaired and non-destructively tested.
- D. Geomembrane shall not be covered at locations which have been repaired until test results with passing values are available.
- E. Damaged geomembrane shall be removed and replaced with acceptable geomembrane if damage cannot be satisfactorily repaired.

- F. Any portion of the geomembrane exhibiting a flaw, or failing a destructive or non-destructive test shall be repaired.
- G. The Contractor shall be responsible for repair of damaged or defective areas. One of the procedures listed below shall be recommended by the Contractor and approved by the Owner:
 - 1. Patching: Used to repair large and small holes, tears, undispersed raw materials, and contamination by foreign matter.
 - 2. Abrading and Re-welding: Used to repair small seam sections (less than twelve (12) inches long).
 - 3. Spot Welding: Spot welding is not allowed.
 - 4. Capping: Used to repair large lengths of failed seams.
 - 5. Removing unsatisfactory material and replacing with new material.
- H. Geomembrane surfaces to be repaired shall be abraded (extrusion welds only) no more than 1/2 hour prior to the repair.
 - 1. Patches or caps shall extend at least six (6) inches beyond the edge of the defect, and all corners of material to be patched and the patches shall be rounded to a radius of at least four (4) inches.
 - 2. The geomembrane below large caps shall be cut to avoid water or gas collection between the two sheets.
- I. Repairs shall be verified using the following procedure:
 - 1. Each patch repair shall be non-destructively tested using methods specified in this Section.
 - 2. Destructive testing may be required at the discretion of the Owner.

3.10 GEOMEMBRANE ACCEPTANCE

- A. Contractor shall retain all ownership and responsibility for the geomembrane until final acceptance by the Owner.
- B. Owner will accept the geomembrane installation when the installation is finished and all required documentation from the Contractor has been received and approved, and verification of the adequacy of all field seams and repairs, including associated testing, is complete.

3.11 MATERIALS IN CONTACT WITH GEOMEMBRANE

A. General

1. Carefully install **materials in contact** with geomembrane surfaces to minimize damage potential.
2. Clamps, clips, bolts, nuts, or other fasteners used to secure geomembrane to each appurtenance shall have **lifespan equal to or exceeding** geomembrane's.

B. Pipes and Other Appurtenances

1. Install geomembrane around appurtenances, such as pipes, protruding through geomembrane as shown in Plans. Unless otherwise specified, initially install geomembrane sleeve or apron around each appurtenance prior to geomembrane installation.
2. After material is placed and seamed, complete final field seam connection between appurtenance sleeve or apron and geomembrane. Maintain sufficient initial overlap of appurtenance sleeve so shifts in location of geomembrane can be accommodated.
3. Extreme care shall be **taken** while seaming around appurtenances because both nondestructive and **destructive** seam testing might not be feasible. Do not damage geomembrane **while** making connections to appurtenances.

END OF SECTION

SECTION 02525

EXTRACTION WELLS

PART 1 GENERAL

1.1 SUMMARY

- A. The Contractor shall provide all labor, equipment, materials, tools, and appurtenances required to complete the work of furnishing and installing the extraction wells as shown on the Drawings.
- B. The Contractor shall comply with applicable codes, ordinances, rules, regulations, and laws of local, municipal, State, or Federal authorities having jurisdiction. The Contractor is responsible for identifying and obtaining all appropriate licenses, approvals, and permits to complete the work of this Section. The Contractor shall provide a "Competent Person" to implement, supervise, and inspect the Work.
- C. Prior to the installation of the extraction wells, the Contractor shall identify and perform any necessary utility mark-outs.
- D. The Contractor shall coordinate the work of this Section with the work of other sections as required.

1.2 DESCRIPTION OF WORK

- A. The approximate locations and depths of the extraction wells are shown on the Drawings. Exact locations shall be determined and field verified by the Contractor and Owner before the installation of the extraction wells is initiated.

1.3 SUBMITTALS

- A. Drilling methods are described herein. The Contractor may propose alternative drilling method(s).
- B. Submit a Statement of Qualifications for the Contractor who will perform the installation. Include resumes of drilling crews and the superintendent. Submit safety records (OSHA 200 logs and Experience Modification Ratings for the last 3 years) and insurance rating. The drilling personnel shall have Occupational Safety and Health Administration (OSHA) 40-hour Hazardous Waste Operator (HAZWOPER) certification, along with required annual refresher training. The Statement of Qualifications shall include documentation of personnel HAZWOPER certification as well as documentation that refresher training is current.

- C. Submit a list of all equipment to be used for the Work described in this Section including proposed drill rigs and associated torque capacity. Submit an installation schedule and update it weekly during the Work.
- D. No work shall be performed until the items discussed above have been favorably reviewed by the Owner.
- E. During drilling of each well, the Contractor shall maintain a detailed daily driller's report and submit reports daily to the Owner. The report shall give a complete description of all formations or material encountered, number of feet drilled, number of hours on the job, shutdowns, feet of casing set, and all other pertinent data.
- F. Upon completion of each well, the Contractor shall submit to the Owner a report including the following:
 - 1. Total depth of the completed well;
 - 2. Depth or location of any lost drilling materials or tools;
 - 3. Nominal hole diameter of the well bore and total depth;
 - 4. Volume and amount of materials (including number of bags) used to fill the annular space;
 - 5. Depth and description of the well casing and screen;
 - 6. Protective casing, plug, cap size, and materials used;
 - 7. Concrete, bentonite, or grout materials used and depths;
 - 8. Number and location of centralizers used;
 - 9. Weather conditions during installation;
 - 10. Name of individual who prepared the report and members of the drilling crew; and,
 - 11. Other pertinent data requested by the Owner.
- G. Following completion of drilling each well, the Contractor shall submit to the Owner signed copies of the driller's log book including the following information:
 - 1. Reference point (i.e., top of casing) for all depth measurements;
 - 2. Depth at which each change of material occurs;
 - 3. Identification of the material of which each stratum is composed;
 - 4. Depth interval from which sample was taken;
 - 5. Name of individual who prepared log and members of drilling crew;
 - 6. Water use during drilling;
 - 7. Penetration resistance during split-spoon sampling (if any);
 - 8. Water levels encountered during drilling;
 - 9. Drill rig type, make, and torque capacity;
 - 10. Split-spoon hammer weight and fall; (if appropriate) and,
 - 11. Other pertinent data requested by the OWNER.

- H. The Contractor shall submit the well coordinates and top-of-casing elevations certified by a Land Surveyor licensed in the State of Illinois.
- I. The Contractor shall submit product data for the following:
 - 1. Casing pipe;
 - 2. Extraction well screen;
 - 3. Drilling fluid materials and additives (if used);
 - 4. Mix design of neat cement and cement grout; and,
 - 5. Pitless adapter.
- J. The Contractor shall submit a completed Well Construction Form for each extraction well constructed. Submit two (2) copies to the Owner upon completion of each extraction well.

1.4 QUALIFICATIONS

- A. The Contractor responsible for the construction of the extraction wells shall be properly licensed and employ only competent workmen for the execution of this Work. All such Work shall be performed under the direct supervision of an experienced driller favorably reviewed by the Owner.
- B. The driller shall be capable of identifying geologic formations, maintaining complete and current well logs and daily notes for the completion report.
- C. The Contractor shall provide satisfactory evidence that all materials to be furnished in performing the Work are new and all equipment to be used is in good working order.

1.5 HANDLING OF MATERIALS

- A. All parts and materials shall be properly protected so that no damage, deterioration, or contamination will occur from the time of shipment until the Work described in this Section is complete.
- B. If in the opinion of the Owner, parts and materials are damaged, deteriorated, or contaminated, the materials will be rejected and immediately removed from the Site. The Contractor shall replace the parts and materials at no additional cost to Owner.

1.6 SITE CONDITIONS

- A. The Contractor shall coordinate access approvals with the Owner. Notify corporations, companies, individuals or authorities owning conduit wires or pipes

running to property or encountered during construction. Protect, support, and maintain conduit, drains, sewers, pipes, and wires.

- B. The Contractor shall not excavate within influence zone of existing footings or foundations without prior approval of the Owner.
- C. The Contractor shall review with and obtain prior approval from the Owner for location of mud or water pits or other temporary excavations for construction purposes.
- D. The Contractor shall perform site grading, filling, and surface stabilization, if necessary, to access the Site with drilling equipment.

PART 2 PRODUCTS

2.1 WELL CASING PIPE

- A. 10.75-inch or 12.75-inch OD Type 304 Schedule 40 (0.365 in. wall thickness) seamless stainless steel pipe.

2.2 SCREEN

- A. Manufacturers:
 - 1. Howard Smith Screen Company.
 - 2. Johnson Screen Company.
 - 3. Or equal.
- B. Type 304 stainless steel telescoping screen, with a nominal diameter of 10 or 12 inches (8.7 and 10.4-inch ID, respectively). The weld ring wall thickness will vary depending on the manufacturer, but should be approximately 0.45 inch. A specially designed packer shall be used at the top of the screen to seal between the outside diameter of the screen and the inside diameter of the casing if the screen is to be telescoped into the 10- or 12-inch ID casing. Contractor shall submit details of the packer for approval.
- C. Screen slot size: 0.040 inch, to be verified by the OWNER during construction.
- D. Add five feet of 10-inch or 12-inch Type 304 stainless steel telescoping 0.005-inch slot screen below the primary screen to act as a sand trap. Close bottom of sand trap screen with factory-welded bottom plate of same material as the screen.
- E. All fittings shall be welded by a certified welder.
- F. Screen shall be continuous-slot, all welded design.

2.3 PITLESS UNIT

A. Manufacturers:

1. Standard Model Monitor PS Industrial Pitless Unit as manufactured by Baker Manufacturing Company.
2. Maass-Baski, Inc. heavy duty Pitless Unit.
3. Or equal.

B. Comply with recommended standards of Pitless Adapter Division - Water Systems Council, National Water Well Association.

C. Design Requirements:

1. Steel pitless case of same size as well casing, with epoxy corrosion resistant coating.
2. Drop pipe: 5- in or 6-inch I.D. threaded connection.
3. Discharge connection: 6-inch threaded connection, 150 psi minimum working pressure.
4. Sealed conduit connection, with neoprene electrical cable seal and O-rings.
5. Lifting lugs.
6. Designed for stresses that may occur during installation, testing, and operation.
7. Stainless steel seating rings.
8. Pitless unit shall be encased in concrete.

2.4 STAINLESS STEEL DROP PIPE

A. Design Requirements:

1. 5.625-in or 6.625-inch OD Schedule 40 (0.280-in. wall thickness) Type 304 stainless steel pipe, threaded and coupled, 21-ft maximum lengths.
2. Pipe shall not support weight of pump. Pump shall be supported by a stainless steel chain with a minimum working load of 3 times the weight of the pump and drop pipe and shall be attached to top of well or pitless adapter as appropriate.

PART 3 EXECUTION

The execution of the project shall be as follows:

3.1 EXAMINATION

- ### A.
- The Contractor shall inspect all materials upon delivery and before placement to

document that they are in the original packaging as supplied by the manufacturer or supplier and free of any deleterious material.

3.2 PREPARATION

The Contractor shall:

- A. Protect existing structures from damage.
- B. Prepare the area for staging of drill cuttings prior to transporting to the temporary spoil stockpile.
- C. The Contractor shall provide access to all extraction wells. Proposed access locations shall be reviewed with the Owner.

3.3 GENERAL

- A. A typical cross-section of proposed wells is included in the Drawings for reference purposes. The well cross-section shall not be interpreted to indicate exact formation, thickness, and material encountered. This information shall be verified during drilling and prior to installation of the screen.
- B. The extraction wells shall be constructed using cable tool methods. However, in the event that drilling by cable tool is determined to be not feasible, another drilling method may be substituted. Drilling Methods shall be approved by the Owner and shall conform to all State and local standards for well construction.
 - 1. Acceptable drilling fluids are potable water and air.
 - 2. Extraction wells shall be drilled straight and plumb.
- C. The Contractor shall provide water for drilling and grouting.

3.4 SCREENED WELL CONSTRUCTION

- A. Drive a 10-inch or 12-inch nominal (10.75-inch or 12.75-in. OD) stainless steel casing 110 to 145 feet below ground surface (bgs) using cable tool methods, or another approved method. Cuttings shall be removed using the appropriate cable tool. The casing sections shall be welded in the field by a certified welder.
- B. Following drilling and sampling of the 10- or 12-inch diameter boreholes, install 10- or 12-inch diameter telescoping screens concentrically within the 10- or 12-inch nominal diameter casings, as casing is pulled back. Screen lengths feet shall be 65 to 95 ft. Actual screen lengths will be determined by the Owner based on the field conditions encountered. Place five feet of 12-inch diameter telescoping screen (0.005 inch slot) below each screen as a sand trap. The boreholes shall be

sampled for stratigraphic classification purposes. Continuous sampling shall be accomplished by collecting small portions of the cable tool cuttings, for inspection and classification.

- C. Terminate upper end of casings at height or depth relative to ground surface indicated on the Drawings.
- D. The natural formation will comprise the filter pack for the well and no well grouting will be accomplished.

3.5 WELL DEVELOPMENT BY MECHANICAL SURGING AND PUMPING

- A. Perform development by mechanical surging and pumping after completion of well construction.
- B. Provide a surge block constructed of two rubber discs between three steel discs. The outside diameter of disc shall be not less than 0.5 in. smaller than the inside diameter of the end fittings (weld rings) of the well screen.
- C. Prior to surging and pumping, clean out any fill from each well.
- D. Provide necessary equipment for performing the well development.
- E. Place the surge block in each well above the screen. Surge, then lower the surge block into each screen and develop intervals by slowly moving progressively downward.
- F. Collect, handle and dispose of well development water in accordance with the requirements of this section.

3.6 DECONTAMINATION

- A. The drill rig and all drilling equipment shall be delivered clean and shall be steam-cleaned upon arrival on-site and prior to leaving the Site. Steam cleaning will not be required between boreholes. Potable water for steam cleaning shall be supplied by the Contractor. Between boreholes, all soil and wastes shall be removed from the drill rig and drilling equipment at the borehole location. Drill cuttings and other solid materials shall be disposed in the temporary spoils stockpile. Liquids are not to be disposed of in the stockpile.

3.7 SOLIDS, LIQUIDS AND PPE HANDLING

- A. All solids, liquids, and personal protective equipment (PPE) used, collected, or encountered during the performance of this Work, including well development water and decontamination water, shall be collected in drums and be delivered to

a consolidation area. These materials shall subsequently be transferred to an appropriate bulk container, e.g. a double walled-tank, contained single wall tank, roll-off box, or other appropriate container provided by Owner. Containerized solids and liquids shall be characterized to determine the proper disposal method and shall be disposed at a facility permitted to handle these materials in accordance with applicable rules and regulations, at Owner's expense.

3.8 WELL PROTECTION

During the progress of the Work, the Contractor shall protect all wells from tampering or the entrance of foreign material.

3.9 WELL ACCEPTANCE CRITERIA

- A. The Contractor shall develop the extraction wells until, in the opinion of Owner, they are:
 - 1. Producing minimum required flow rate;
 - 2. Producing water completely free of drilling fluids; and,
 - 3. No increase in well specific capacity is observed following successive development periods.
- B. All boreholes shall be constructed and casing installed plumb and true to line.
- C. All casing, screens, and caps shall be set to the depths directed by Owner.
- D. All well identification numbers, dates of completion, and permit numbers shall be imprinted inside the well or sump cover.
- E. All residual materials (bags, crates, containers, and miscellaneous debris) shall be removed from the Site, or placed into on-site solid waste dumpsters.
- F. No payment will be due to the Contractor if he fails to meet all of the above requirements.

END OF SECTION

SECTION 02526

SUBMERSIBLE WELL PUMP AND MOTOR

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

- A. The Contractor shall provide all labor, equipment, materials, tools, and appurtenances required to complete the work of furnishing and installing submersible well pumps and motors as shown on the Drawings, as specified herein, and as otherwise required by the Owner.
- B. The work of the Section includes furnishing and installing submersible pumps, motors, and drop pipe in the extraction wells, furnishing and installing meter/sampling vaults, appurtenant pipe, valves, flow meters (furnished by others) and fittings in the vaults, and crushed rock pads at the wells. Two of the pumps shall be installed in a 12-inch well casing, and one pump shall be installed in a 10-in. well casing. The pump intakes and discharge lines shall be installed at the approximate elevations shown on the drawings.

1.2 CONTRACTOR SUBMITTALS

- A. Shop Drawings:
 - 1. Drawing of proposed surface plate and discharge head based on certified points.
 - 2. Installation drawing of pump cross-section installed in well.
 - 3. Parts list and descriptions including such items as manufacturer, make, model, style, type, weights, material, coatings, finishes, and references to appropriate standards.
 - 4. Pump manufacturer's curve showing principal characteristics of proposed pump including:
 - a. Relation between delivery and head.
 - b. Relation between efficiency and delivery.
- B. Miscellaneous:
 - 1. Pump manufacturer's statement of overall efficiency guarantee for pumping unit, under the conditions specified in Section 3.2.2.
 - 2. Pump schedule showing make and model number.
- C. Submit documents to the Owner.

- D. Provide record copies of **the Shop Drawings** as part of the Technical Manuals (O&M Manual).

1.3 QUALITY ASSURANCE

- A. Pump installer shall be **licensed** in the State of Illinois.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Prevent dirt, water, and **chemicals** from entering inside the discharge pipe and equipment.
- B. Where possible, store **materials** and equipment inside to protect from weather. If it is necessary to store **materials** and equipment outside, store in a manner such that the materials and **equipment** are elevated above grade.

1.5 SITE CONDITIONS

- A. Pump equipment **specified** in this Section is based on anticipated pumping conditions and is **subject** to change following well test results.
- B. Modifications to **pumping** equipment, if necessary, will be made by written Change Orders.
- C. Do not order **pumping** equipment until well has been tested and pump design conditions are **verified** by the Owner.

PART 2 PRODUCTS

2.1 GENERAL The pump and motor **shall** be designed for continuous submerged operation. The pump bowls, impellers, guide vanes, **strainer**, and check valve shall be 300 Series stainless steel. The shaft and coupling shall be 300 or 400 series stainless steel. The motor shall be an induction motor designed for continuous **underwater** operation in conformance with NEMA standards. The motor shall be water filled for cooling and lubrications and shall not utilize oils and greases.

- A. Proposed equipment will **not** be considered if it has not demonstrated its reliability and efficiency **on installations** of similar units of approximately the same capacity and under **conditions** corresponding to this installation. Submit such information to the Owner.
- B. Working parts shall be **readily** accessible for inspection and repairs, easily duplicated, and replaced.

- C. Pump bearings shall be ample in size and water lubricated. Bearings and similar parts shall have temperature rise not to exceed limit of safety and good practice for such parts with water temperature of less than 68°F.
- D. Apparatus shall be free from shock, vibration, and noise under conditions of load.
- E. Proportion pump parts for stresses that may occur during continuous operation and for additional stresses that may occur during fabrication, erection, and intermittent or continuous operation.
- F. Design for pumps, appurtenances, and cable to be capable of continuous submergence under water without loss of watertight integrity to depths as shown on the Drawings.

2.2 PUMPING EQUIPMENT

- A. Manufacturers (see table below):
 - 1. Grundfos Model 625S400-2A (Wells Ew-1 and -2); or
 - 2. Grundfos Model 475S300-3 (Well EW-2);
 - 3. Or equal.

Comparison of Pump Specifications:

	Range	300 gpm		450 gpm		550, 667 gpm	
		Total Dynamic Head	Efficiency	Total Dynamic Head	Efficiency	Total Dynamic Head	Efficiency
	[gpm]	[feet]	[%]	[feet]	[%]	[feet]	[%]
475S400-3 (30 HP)	280 to 640	223	67	172	75	140	70
625S400-2A (40 HP)	125 to 840	214	58	190	70	150	80

The pumps will be selected after performance testing of the wells. It is anticipated that the Model 475S300-3 pump will have to be used in Well EW-2, which is a 10-in. diameter well.

- B. Provide submersible well pumping equipment in accordance with the requirements shown on the Drawings, or as otherwise specified by the OWNER. Pumps will utilize variable frequency drives specified in another section that are compatible with each pump, as recommended by the pump manufacturer.

- C. Design to prevent damage to pumps and motors in the event that the units should be operated in the wrong direction.
- D. Pumps shall be sized to provide at least 667 (550 for Well EW-2) gallons per minute flow against a total head of at least 125 feet, depending on final design parameters for the effluent pipeline. The pump efficiency shall be above 70% for the projected maximum pumping rate and total dynamic head.
- E. Pumps provided shall be of the same manufacturer for ease of operation, maintenance, and repair.

2.3 CHECK VALVES

- A. Manufacturers:
 - 1. Lakewood.
 - 2. Or equal.
- B. Provide one (1) check valve of the same size as pump drop pipe if the pump does not have a check valve built in. Do not provide check valve if the pump has a built-in check valve.
- C. Stainless steel construction, stainless steel spring, threaded ends, double disc type.
- D. Neoprene tube around upper cross-bar to absorb seat opening shock.

2.4 ISOLATION AND AIR RELEASE VALVES

- A. Manufacturers:
 - 1. Milliken
 - 2. Dezurik
 - 3. Keystone
 - 4. APCO
 - 5. Or equal
- B. Provide plug valves as shown on Drawings, so that each well can be fully isolated from the system (for example, during repairs). This valve shall be installed a minimum of 12 in. downstream from the center of the flow meter .
- C. Provide one isolation valve per pump, located on conveyance pipe inside enclosure.

- D. (Addendum 1) Furnish and install one APCO 2-in. Model 200 or equal air release valve per pump with a ½-in. diameter orifice. . The sampling tap and tap for the air release valve may be combined if Contractor wishes using appropriate tees and other fittings. One vendor for this valve is Ulmer Equipment Co. (John Moore, 636-343-4606). In any event, this valve shall be installed at least 1 ft downstream or 2.5 ft upstream of the center of the magnetic flow meter in the valve vault by welding a 2-in. dia stainless steel half-coupling in the top of the 6-in. dia stainless steel discharge line from the well. The air release valve shall be primed and painted with a two-coat epoxy paint by the valve manufacturer.

2.5 (ADDENDUM 1) MAGNETIC FLOW METER:

- A. The flow meters will be furnished by others for installation in the pump discharge line under this contract. The flow meter will be a 6-in. Krohne Aquaflux magnetic flow meter with 125-lb ANSI flanged ends. The remote signal converter will be furnished and installed by others.

2.6 (ADDENDUM 1) VIBRATING WIRE PRESSURE TRANSDUCER

- A. Contractor shall install Geokon pressure transducer furnished by Owner) in each well within a 1-in. diameter stainless steel pipe extending to the top of the submersible pump. The cable from the pressure transducer shall terminate in a Geokon LAB3 junction box mounted on the pitless adapter.

2.7 ELECTRIC MOTOR

- A. Manufacturers:
1. Franklin.
 2. Grundfos.
 3. Hitachi
 4. Mitsubishi
 5. Pleuger
 6. Or equal.
- B. Provide submersible, 30- or 40-horsepower, 480V, 3-phase, 3450 rpm, 60 Hz electric motors
- C. High thrust capacity with heavy thrust bearings.
- D. Highest grade heavy-walled seamless steel motor housing.
- E. Accurately machined shaft and rotor assembly, dynamically balanced to ensure vibration-free operation.

- F. Capable of sustaining minimum of 3 starts/hr, 24 hrs/day, 365 days/yr.
- G. Motors shall be compatible with Reliance SP600 Variable Frequency Drives for motor speeds between 500 and 3500 rpm.

2.6 PUMP CABLE

- A. Provide submersible cable in accordance with AWWA E101 and this Section.
- B. Design pump cable entry water seal to ensure watertight and submersible seal.
- C. Do not use epoxies, silicones, or other secondary sealing systems.
- D. Install suitable motor cable for submersible pump applications and indicate by code or legend permanently embossed on cable.
- E. Provide four (4) or more separate conductors, including one (1) for ground.
 - 1. 1000V UL Flexible Motor Supply Cable /UL 1277 600V TC/1000V CSA shielded tray cable.
 - 2. Cable with four (4) or more conductors shall be jacketed with oil and water-resistant material.
 - 3. Cable shall be rated 1000V UL for use with variable frequency drivers.
- F. Cable shall extend from the motor to the junction box at the top of the well casing.
- G. Provide stainless steel clamps connected to the pump discharge pipe at not less than 10-foot intervals.
- H. Provide stainless steel cable guard at pump assembly.

2.7 SOURCE QUALITY CONTROL

- A. Factory test submersible pump and cable and perform insulation tests before and after testing.
- B. Perform factory test with job motor driving pump.
- C. Test points shall include shut-off head, rated head, and at least three (3) other points as required for accurate curve plotting.

- D. Test data computations **shall be made** to provide field head-discharge curves, field wire to water efficiency curves, and field power consumption in kwh/1,000 gal at performance point.
 - 1. Do not include **velocity head**, but include internal pump and screen losses, including built-in check valve, in performance curves.
 - 2. Correct test results to show field performance at speed which unit will operate with **480V at motor terminals**.
- E. Pump motors shall be **non-overloading** throughout the entire operating range.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install pumping equipment **complete** and in accordance with the manufacturer's recommendations, **approved submittals**, and to the satisfaction of the Owner.
- B. Install pump and discharge **pipe** in accordance with Section 2 of this specification.

3.2 FIELD QUALITY CONTROL

- A. **Manufacturer's Field Services:**
 - 1. Supplier's or **manufacturer's** technician for the equipment specified herein shall be present **at the Site** for minimum of two (2) man days, travel time excluded, for **start-up support** and training of the OWNER'S personnel for the operation, **maintenance**, troubleshooting, and system-related areas.
- B. **Tests:**
 - 1. Conduct **pumping test** to demonstrate field performance of pumping equipment in accordance with Section 2.3.5 of this section.
 - 2. Pump and motor **shall operate** without excessive vibration and shall operate at a **pumping capacity** and field efficiency which is consistent with the field total **dynamic head** conditions and approved performance curve data for the **pumping equipment**.
 - 3. Tests will not be **considered complete**, nor will pumping equipment be accepted, if the **requirements** of this Section are not met.

END OF SECTION

- **Identify a designated ABI representative who will serve as an on-site point-of-contact and escort. This person shall have a good knowledge of the oil storage locations/characteristics at each facility;**
- **Provide access to each storage location at the facility;**
- **Provide Contractor with an electronic copy of each existing SPCC Plan in Microsoft Word in advance of the site visits;**
- **Provide Contractor with electronic copies of available building layout diagrams that can be directly used by Contractor for subsequent development and use in the revised SPCC Plan; and**
- **Provide Contractor with currently known inventory of transformers or other equipment using 55 gallons of oil or greater.**

SECTION 02550

EFFLUENT PIPELINE AND APPURTENANCES

1.0 GENERAL

1.1 SECTION INCLUDES:

- 1.1.1 Furnishing and installing HDPE pipe and fittings and connecting pipeline to 6-in. Class 150 flanges at the three well discharge lines and to the 12-in. Class 150 flanges at both ends of the 20-in. OD HDPE pipe installed under the levee by others
- 1.1.2 Furnishing and installing ductile iron pipe and fittings and necessary pipe supports at discharge point, including the 36-in. diameter pier foundations and the anchors to be installed in the walls of existing Manholes B and C
- 1.1.3 Removing existing fence as required and furnishing and installing matching additional chain-link fence at discharge point (Addendum 1)
- 1.1.4 Furnishing and installing combination air valve and manhole at high point of effluent pipeline riverward of the levee
- 1.1.5 Furnishing and installing buried shut-off plug valve in pipeline riverward of levee
- 1.1.6 Furnishing and installing valves and sampling instrument
- ~~1.1.7~~ (Addendum 1-Furnishing and installing wire in conduit from flowmeter signal converter to Influent PLC panel at P-Chem Plant about 1,000 ft west of discharge point.
- 1.1.8 Designing, furnishing, and installing electrical service at discharge point, heat tracing, pipe insulation, area lighting, and all electrical distribution, panels, and hookups.
- 1.1.9 (Addendum 1) Designing, installing, maintaining, and removing measures for preventing erosion during construction.

- 1.1.10 (Addendum 1) Grading, seeding, and fertilizing areas disturbed by construction to reestablish vegetative cover at least equal to the cover that existed before construction.

1.2 REFERENCES

- ASTM D 638: Test Method for Tensile Properties of Plastics.
- ASTM D 790: Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
- ASTM D 1238: Test Method for Flow Rates of Thermal Plastics Molding and Extrusion Materials.
- ASTM D 1505: Test Method for Density of Plastics by the Density Gradient Technique.
- ASTM D 1599: Test Method for Short Time Hydraulic Failure Pressure of Plastic Pipe Materials.
- ASTM D 1693: Test Method for Environmental Stress Cracking of Ethylene Plastics.
- ASTM D 2122: Method for Determining Dimensions of Thermal Plastic Pipe and Fittings.
- ASTM D 2321 Recommended Practice for Underground Installation of Flexible Thermoplastic sewer Pipe
- ASTM D 2837: Method for Obtaining Hydrostatic Design Basis for Thermal Plastic Pipe Materials.
- ASTM D 3350: Polyethylene Plastics Pipe and Fitting Material.
- ASTM F 714: Polyethylene (PE) Plastic Pipe Based on Outside Diameter.
- ASTM F 1248: Determination of Environmental Stress Crack Resistance (ESCR) of Polyethylene Pipe.

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Addendum 1&2 4/22/03, 4/24/03

Final 7/3/03

ASTM D 4218:	Test Method for Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.
ASTM D 1248:	Specification for Polyethylene Plastics Molding and Extrusion Material.
ASTM D 2240:	Test Method of Rubber Property - Durometer Hardness.
ASTM D 695:	Test Method for Compressive Strength of Rigid Plastics.
ASTM D 256:	Test Method for Impact Resistance of Plastics and Electrical Insulating Material.
ASTM D 696:	Test Method of Coefficient of Linear Thermal Expansion of Plastics.
ASTM C 177:	Test Method for Steady-State Heat Flux Measurement and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
ASTM D 746:	Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
ASTM D 152S:	Test Method for Vicat Softening Temperature of Plastics.
AWWA C104	Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C105	Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C110	Ductile-Iron and Gray-Iron Fittings, 3 In. Through 48 In. (75 mm through 1200 mm), for Water and Other Liquids
AWWA C111	Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115	Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C151	Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids
AWWA C153	Errata Nov 1996) Ductile-Iron Compact Fittings, 3 In. Through 24 In. and 54 In. through 64 In. for Water Service

1.3 SUBMITTALS

- 1.3.1 Submit certifications, **manufacturer's** data, shop drawings, test results, and records as necessary to show that **materials**, methods, and workmanship meet or exceed the requirements of these specifications.
- 1.3.2 Submit the following to the Owner for review and acceptance prior to shipment of the pipe:
 - 1.3.2.1. Proposed profile drawing of pipeline. The pipeline shall be constructed at grades that **maintain** minimum 36-in. of cover over the pipe and that minimize the **number** of high points in the line from beginning to end. The profile shall be **based** on a ground elevation survey performed by Contractor along the proposed pipeline alignment. Ground elevations shall be obtained at **all breaks** in grade and at a minimum of every 50 ft.
 - 1.3.2.2. A statement in writing from the pipe manufacturer that it is listed with the Plastic Pipe Institute as an extruder for polyethylene resin being used to manufacture the pipe for this project.
 - 1.3.2.3. Catalog information confirming the pipe conforms to the requirements of these specifications.
- 1.3.3 Submit the following to the Owner for review and acceptance prior to shipment of the fittings and instruments:
 - 1.3.3.1 Catalog data and **all dimensions** for HDPE, ductile iron, and stainless steel pipe fittings, if any.
 - 1.3.3.2 Catalog data and **dimensions** for all valves and instruments to be furnished and installed as part of the discharge pipeline.
 - 1.3.3.3 Large scale shop drawings (plan, elevation, and detail) showing the arrangement of the discharge line, elbows, flow meter, sampling instrument and **tap**, valves, drainage taps, and discharge piping to Existing Manholes B and C.

2.0 PRODUCTS

2.1 HDPE PIPE MATERIALS

2.1.1. Physical Properties for pipes and fittings:

Typical Physical Properties*

Property	Specification	Units	Nominal Values
Material Designation	PPI/ASTM	---	PE3408
Material Classification	ASTM D1248	---	III C 5 P34
Cell Classification	ASTM D3350	---	345434C
Density (3)	ASTM D1505	gm/cm ³	0.955
Melt (4)	Flow ASTM D1238	gm/10 min	0.11 @ 2.16 kg***
Flex (5)	Modulus ASTM D790	psi	135,000
Tensile (4)	Str. ASTM D638	psi	3,200
ESCR (3)	ASTM D1693	F ₀ , Hrs	F ₀ >5,000
HDB @ (4)	73°F ASTM D2837	psi	1,600
U-V (C)	Stabilizer ASTM D1603	% C	2.5
Hardness	ASTM D2240	Shore "D"	65
Compressive Strength (Yield)	ASTM D695	psi	1,600
Tensile Strength @ Yield(Type IV Spec)	ASTM D638(2"/min)	psi	3,200
Elongation @ Yield	ASTM D638	% minimum	8
Tensile Strength @ Break(Type IV Spec)	ASTM D638(2"/min)	psi	5000
Elongation @ Break	ASTM D638	% minimum	750
Modulus of Elasticity	ASTM D638	Psi	130,000
ESCR (Cond A, B, C: Mold. Slab)	ASTM D1693	F ₀ , Hrs	F ₀ >5,000**
Compressed Ring (Pipe)	ASTM F1248	F ₅₀ , Hrs	F ₅₀ >3,500**
Slow Crack Growth	Battelle Method	Days to Failure	F ₀ >64
Impact Strength (IZOD) (.125" THK)	ASTM D256(Metho d A)	in-lb/in Notch	42
Linear Thermal Expansion Coef.	ASTM D696	in/in/°F	1.2 x 10 ⁻⁴
Thermal Conductivity	ASTM C177	BTU-	2.7

Property	Specification	Units	Nominal Values
		in/Ft ² /hrs/ ⁰ F	
Brittleness Temp.	ASTM D746	⁰ F	<-180
Vicat Soft Temp.	ASTM D1525	⁰ F	+257
Heat Fusion Cond.	---	psi @ ⁰ F	75 @ 400

This list of Typical Physical Properties is intended for basic characterization of the pipe, and does not represent specific determinations or specifications.

**Tests were discontinued because no failures and no indication of stress crack initiation.

***Average Melt Index Value with a standard deviation of 0.01.

2.1.2 Materials used for the manufacture of polyethylene pipe and fittings shall be extra high molecular weight, high density ethylene/hexane copolymer PE 3408 polyethylene resin meeting the above physical properties and pipe performance requirements. The material shall be listed by the Plastics Pipe Institute in PPI TR-4 with a 73⁰F hydrostatic design basis rating of 1600 psi and a 140⁰F hydrostatic design basis rating of 800 psi. The PPI Listing shall be based on ASTM D2837 and PPI TR-3 testing and validation of samples of the pipe manufacturer's production pipe.

2.2 PIPE

2.2.1. HDPE Pipe

2.2.1.1. HDPE pipe shall be produced with nominal physical properties outlined in Paragraph 2.1.1 and to the dimensions and tolerances specified in ASTM F714. Pipe shall be inspected per industry accepted manufacturer standards for:

Diameter
Wall Thickness
Concentricity
Joint Length
Ovality
Toe-In
Overall Workmanship
Inspection on ID & OD
Print Line

Pipe shall be homogeneous throughout and free of visible cracks, holes, voids, foreign inclusions or other deleterious defects, and shall be identical in color, density, melt index and other physical properties throughout.

2.2.1.2 Pipe shall be in compliance with the physical and performance requirements of Paragraph 2.1.1.

2.2.1.3. Pipe sizes and types:

- a. 6.625-in. outside diameter, DR 11, Driscopipe, or approved equal.
- b. 12.75-inch outside diameter, DR 21, Driscopipe, or approved equal.
- c. (Not In Contract: 20-inch outside diameter, DR 13.5, Driscopipe, or approved equal.)

2.3 FITTINGS

2.3.1 Furnish shop fabricated HDPE fittings as shown on the Drawings or required by the work. Fittings shall be molded or custom fabricated and shall have the same pressure ratings and wall thicknesses, or greater, than the pipe connected thereto.

2.3.2 Furnish plug valve in HDPE pipeline riverward of levee as detailed on drawings. Plug valve shall be a 12-in. Milliken Model 600N1-BG or equal valve with mechanical joint ends, a buried gear actuator with extended 2-in. nut and a valve box of appropriate length for the location selected. The valve shall meet or exceed the specification in Paragraph 2-6 of this section. The exterior of the valve shall be coated with two coats of the manufacturer's standard epoxy coating. Contractor shall install valve within 100 ft of the riverside toe of the levee.

2.3.3 (Addendum 1) **Combination Air Valve:** Furnish and install APCO Model 147C (or equal) 3-inch combination air valve with 1/2-in. dia orifice in manhole riverward of levee at high point in effluent pipeline. One vendor for this valve is Ulmer Equipment Co., John Moore, telephone 636-343-4606. Valve may be connected to 12.75-in. OD HDPE pipeline by installing a double strap ductile iron saddle or by installing an HDPE DR11 branch tee with appropriate HDPE DR11 fittings as recommended by the pipe manufacturer. Valve shall be primed and painted with two-coat epoxy paint as recommended by valve manufacturer.

2.4 DUCTILE IRON PIPE AND FITTINGS

Ductile-iron pipe and fittings shall conform to the following requirements. Thickness class of pipe and rated working pressure shall be as specified herein or as shown on the Drawings. All ductile iron pipe shall be Standard Thickness Class 350 or heavier. All ductile iron pipe fittings shall be mechanical joint or flanged fittings, pressure class 350 or heavier.

- 2.4.1 Pipe Ductile-iron pipe shall conform to the requirements of ANSI/AWWA C150/A21.50, Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds for Water or Other Liquids, and ANSI/AWWA C110/A21.10, Flanged Ductile-Iron Pipe with Threaded Flanges.
- 2.4.2 Fittings Ductile-iron pipe fittings shall conform to the requirements of ANSI/AWWA C110/A21.10, Ductile-Iron and Gray-Iron Fittings, 3-inch through 48-inch, for Water and Other Liquids, and ANSI/AWWA C153/A21.53, Ductile-Iron Compact Fittings, 3-inch through 12-inch, for Water and Other Liquids.
- 2.4.3 Joints Rubber-gasket joints for ductile-iron pipe and fittings where either mechanical or push-on joints are used shall conform to the requirements of ANSI/AWWA C111/A21.11, Rubber-Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe and Fittings. Unless otherwise specified or indicated on the Drawings, all buried joints shall be mechanical joints and all other joints shall be flanged.
- 2.4.4 Lining Interior lining for ductile-iron pipe and fittings shall conform to the requirements of ANSI/AWWA C104/A21.4, Cement Mortar Lining for Ductile-Iron Pipe and Fittings for Water. Unless otherwise specified, special fittings and appurtenances shall be the same material as the pipe.

2.5 CHECK VALVE

The check valve at the end of the discharge pipeline shall be a 12-inch diameter Valmatic Model 518 Swing-Flex, Milliken Model 851, or equal full body flanged type with a domed access cover and only one moving part, the valve disc. The valve shall be equipped with a backflush device to enable flushing out the valve with backward flow. The straight pipe length downstream of the check valve shall be at least three pipe diameters. The valve body shall have full flow equal to the nominal pipe diameter at any

point through the valve. The seating surface shall be on a 45-degree angle to minimize disc travel. The top access port shall be full size, allowing removal of the disc without removing the valve from the pipeline. The access cover shall be domed in shape. The disc shall be of one-piece construction, precision molded with an integral Oh-ring type sealing surface and contain steel and nylon reinforcements in both the Memory-Flex and central disc areas. The flex portion of the disc shall be warranted for twenty-five years. Non-slam closing characteristics shall be provided through a short 35-degree disc stroke and a Memory-Flex return action. The valve body and cover shall be ASTM A126, Class B cast iron. The disc shall be Buna-N (NBR), ASTM D2000-BG. The interior and exterior of the valve shall be coated with a fusion bonded epoxy. The valve shall be cycle tested 1,000,000 times with no sign of wear or distortion of the valve disc or seat and shall remain drop tight at both high and low pressures. The test results shall be independently certified. Bolts and nuts for the flanges shall be Type 316 stainless steel.

2.6 PLUG VALVES

Plug valves shall be of the non-lubricated, eccentric type. Flanged valves shall be manufactured in accordance with ANSI B16.1, Class 125/150, including flange thickness as required by AWWA C504-00, Table 2 and comply with MSS-SP-108 (Eccentric Plug Valves) in all respects. Mechanical joint ends shall comply with AWWA/ANSI C-111-92. Valves shall be designed and manufactured to have a minimum wall thickness compliant to AWWA C504-00. Plug shall be round through 12" and rectangular for sizes 14" and larger. Lay lengths shall be compliant to MSS-SP-108 for all valve sizes. Valve bodies shall be of ASTM A-126, Class B cast iron in accordance with AWWA C-504-00, Sec. 4.4.2.1. or ASTM A-536 ductile iron. Valves 3" and larger shall be furnished with a welded-in overlay seat of not less than 90% nickel in accordance with AWWA C-507-85, Sec. 3.2.3.5. Nickel thickness shall be not less than .125". Sprayed, plated screwed-in seats are not acceptable. Plugs shall be of ASTM A-536, Grade 65-45-12 high strength ductile iron in conformance with AWWA C-504-00, Sec. 4.4.2.2. or solid one piece cast iron. Two piece plugs or plugs with internal cavities are not acceptable. The plug shall be of one-piece solid construction with PTFE thrust bearings on the upper and lower bearing journals to reduce torque and to prevent dirt and grit from entering the bearing and seal area. Valves that do not isolate the bearing area from debris are not acceptable. Valves shall be furnished with replaceable sleeve type bearings conforming to AWWA C-504-00, Sec. 4.5.6.4 and AWWA C507-85, Sec. 3.2.4. Bearings shall be of sintered, oil impregnated Type 316 stainless steel ASTM A-743,

Grade CF8M. Port areas shall provide for the following minimum flow coefficients or be a minimum of 100% port. **Valve Size Cv (GPM) :12" 7,000.** All plug valves, for whatever service, shall be capable of passing "pigging" cleaning equipment in either direction and manufacturer shall so certify that this may be done without the use of special equipment. Valve Shaft seals shall be of the dual "U" cup type in accordance with AWWA C-504-00, Sec. 4.5.7.1. Seals shall be self adjusting and repackable without removing the bonnet from the valve. Packing adjustment shall not result in an increase in plug friction or resulting torque. Packing replacement shall be achieved without need to cut packing during reinstallation and not require cap removal. Single piece packing arrangements are not acceptable. **Worm gear operators are required for this project** and shall be of heavy-duty ductile iron construction with ductile iron quadrant supported on top and bottom by oil impregnated bronze bearings. The worm gear and shaft shall be manufactured of hardened steel and run on high efficiency roller bearings. Gear shall have both open and closed stops, shall be flush-mounted to the valve exposing no portion of the plug stem, and shall be rated for the valves design pressure rating for bi-directional shut off. Buried service gears shall be designed and certified to withstand input loads of up to 300 ft. lbs. minimum without damage. Valves shall be designed and manufactured to shut off bubble tight at 175 psi for valves 2 1/2" through 12" and at 150 psi for valves 14" through 36". Valves 42" and larger shall be certified bubble tight at 125 psi. Each valve shall be given a bi-directional hydrostatic seat test with the test results being certified by the manufacturer when required. All actuation shall be supplied and fully warranted by the plug valve manufacturer. Certified copies of Proof-of-Design test reports shall be furnished as outlined in AWWA C-504-00, Section 5.2.4. Plug valves shall be Millcentric Series 601 / 600 as manufactured by Milliken Valve Company of Bethlehem, PA, or equal.

2.7 FLOWMETER

Addendum 2 (Meter furnished by Owner, to be installed by this Contractor) The flowmeter shall be an 8-in. Krohne Aquaflux or equal magnetic flowmeter with hard rubber lining, Hastelloy C electrodes, 150-lb ANSI flanged ends, IP67 rated, 316SS grounding rings, IFC020F integral signal converter, 115AC powered, NEMA 4X rated, digital display of rate and total. Install meter with the minimum upstream and downstream lengths (40 in. and 16 in., respectively, measured from the centerline of the meter) of 8-in. diameter straight ductile iron pipe with flanged ends. Furnish and install

12-in. by 8-in. concentric ductile iron reducers upstream and downstream of the flowmeter as required.

2.8 PIPE SUPPORTS

Contractor shall set elevation of pipe such that it will clear the tops of the concrete walls of Existing Manholes B and C. Where the pipe is above the ground surface, it shall be supported at least every 25 ft using pipe supports equal to or better than Piping Technology & Products, Inc. Figure 48 pipe saddle supports with U-bolt (telephone 713-731-0030), 3.5-inch outside diameter Sch 80 steel pipe, and ¾-in. thick stainless steel anchor plates welded to the pipe. The support assemblies shall be galvanized, except for the stainless steel anchor plates. Pipe saddle supports shall be connected to 3-inch diameter Sch 80 steel pipe as recommended by saddle support manufacturer. The supports shall be anchored to concrete supports using four ¾-in. diameter threaded 18-8 stainless steel L-style anchor bolts with 6 in. of threads at least 18 in. long (including the threaded portion) with a minimum 2-in. long leg at 90 degrees. Stainless steel anchor plates shall be attached to anchor bolts with hex-head heavy stainless steel nuts and washers above and below plates as shown on drawings to permit small adjustments in elevation during installation and to provide for possible settlement of each foundation. Galvanized insulation protection shields (equal to or better than Piping Technology Products, Inc. Figure 183) shall be installed at each pipe support to preclude crushing the insulation around the pipe. Alternately, galvanized pipe covering saddles may be used. Dielectric material shall be included between galvanized shields and aluminum pipe jacket to prevent galvanic corrosion due to dissimilar metals.

2.9 FOUNDATIONS

Reinforced concrete piers 36 inches in diameter and at least 3 ft deep shall be constructed to support the aboveground piping and fittings as shown on the drawings. The locations of the piers shall be selected by the Contractor to miss underground piping in the area. The concrete shall meet the requirements of Section 03300. Anchor bolts and reinforcing steel shall be securely held in place during concrete placement. Sonotube cardboard forms may be used for the piers and stripped down to the ground surface after the concrete has cured for 7 days.

The sampling instrument shall be supported on a reinforced concrete slab as shown on the drawings.

2.10 INSULATION AND HEAT TRACING

Certain aboveground pipe, valves, flow meters, and fittings shown on drawings shall be insulated with 1.5-in. thick fiberglass insulation enclosed in a 0.016-in. thick embossed aluminum jacket. Heat tracing shall be designed to prevent water from freezing during low ambient temperatures. Contractor shall design the heat tracing and submit the design calculations and details for approval. The heat tracing shall be designed to keep the water from freezing at a minimum ambient temperature of -40° F. The maximum intermittent ambient exposure temperature shall be 105° F for design purposes.

2.11 CONTINUOUS WATER SAMPLER

(Addendum 2) The water sampler shall be an all-weather American Sigma 900 MAX refrigerated sampler, 115 VAC, with a 6-ft power cord and pump tube insert. It shall be equipped with a set of four 3-gallon polyethylene bottles, a distributor with arm (2/4 bottle, AWRS), a 10-ft long multi-purpose half cable, and integral flow meter with RS232 output and cable. One vendor who has this sampler is Ressler & Associates, Inc. (Jim Hopkins, telephone 636-391-8992).

2.12 (ADDENDUM 1) COMBINATION AIR VALVE

Furnish and install APCO Model 147C (or equal) 3-inch combination air valve with ½-in. dia orifice in manhole riverward of levee at high point in effluent pipeline. One vendor for this valve is Ulmer Equipment Co., John Moore, telephone 636-343-4606. Valve may be connected to 12.75-in. OD HDPE pipeline by installing a double strap ductile iron saddle or by installing an HDPE DR11 branch tee with appropriate HDPE DR11 fittings as recommended by the pipe manufacturer. Valve shall be primed and painted with two-coat epoxy paint as recommended by valve manufacturer

3.0 EXECUTION

3.1 HDPE PIPE PREPARATION

3.1.1 Inspect pipe and fittings prior to assembly. Mark and remove from the job site all materials that are damaged or do not meet the specifications.

3.1.2 Sections of pipe with cuts or gouges in excess of ten percent of the wall thickness of the pipe shall be cut out and removed.

- 3.1.3 Confirm location of pipe, fittings and connections.

3.2 HDPE PIPE INSTALLATION - GENERAL

- 3.2.1 Install pipe to the lines indicated on the Drawings.
- 3.2.2 Handle and install pipe in accordance with the manufacturer's recommendations.
- 3.2.3 Joining
 - 3.2.3.1 Butt heat fusion weld the joints in strict accordance with the manufacturer's instructions. The butt fusion equipment shall be capable of meeting all conditions recommended by the pipe manufacturer, including, but not limited to, temperature requirements of 400°F, alignment and 75 psi interfacial fusion pressure.
 - 3.2.3.2 Joint weld strength shall be equal to or greater than the tensile strength of the pipe.
 - 3.2.3.3 Socket fusion shall not be used.

3.3 LAYING AND BEDDING THE DUCTILE IRON PIPE

- 3.3.1 Pipe shall be installed to the lines and grades shown on the Drawings with bell socket ends aligned upstream unless otherwise specified. The pipe shall be installed in accordance with the manufacturer's recommendations, unless otherwise specified. Two copies of the Ductile Iron Pipe manufacturer's installation instructions shall be provided to The Owner before any pipe placement.
- 3.3.2 The pipe shall be firmly and uniformly bedded within the trench throughout the entire length of the pipe section to the depth and in the manner specified. Bell holes for flanged, push-on, or mechanical joint pipe shall be provided as necessary to allow space for joint assembly and to permit the pipe barrel to be uniformly supported on the bedding.
- 3.3.3 Joints and Connections: Pipe joints shall be mechanical joints and shall be sound and watertight at a pressure of 80 psi. Install underground piping with restrained joints at horizontal and vertical changes in direction. Where ductile

iron pipe or fittings are connected to HDPE pipe, mechanical joint adapters shall be fused to the HDPE pipe (Driscopipe 4000 Series or equal).

- 3.3.4 Thrust Restraint - Plugs, caps, tees, wyes and bends deflecting 11.25 degrees or more, either vertically or horizontally shall be provided with thrust restraints. Valves shall be securely anchored or shall be provided with thrust restraints to prevent movement. Thrust restraints shall be restrained joints or concrete thrust blocks as detailed on the drawings.

3.4 HANDLING THE PIPE.

The contractor shall furnish all equipment and facilities needed to handle, store, and place the pipe without damaging the pipe, lining, or coating. Pipe coating or lining that is damaged shall be repaired using methods recommended by the manufacturer unless otherwise specified herein.

3.5 PRESSURE TESTING

Pressure testing of the conduit shall be conducted as follows:

- 3.5.1 Placement of backfill before pressure testing shall be as specified in the section on backfill.
- 3.5.2 Before pressure testing, the pipeline shall be flushed and free of all foreign material.
- 3.5.3 The pipeline shall not be pressure tested until concrete for anchor and thrust blocks has attained the minimum specified compressive strength unless other specified methods of thrust restraint are provided.
- 3.5.4 The total pipeline or continuous section of pipeline to be tested shall be filled with clean water at a rate not to exceed the maximum specified and tested at 80 psi.
- 3.5.5 The section of pipeline being tested shall be allowed to stand full of water for a minimum of 24 hours before the start of pressure and leakage tests. Test pressures shall be held constant for 2 hours. When the amount of water loss exceeds the maximum allowable loss specified, the leak(s) shall be repaired or otherwise corrected and the pipeline shall be re-tested. The testing procedure shall be repeated until the requirements of the Specifications are met.

- 3.5.6 Except for joint material **setting** or where concrete thrust blocks necessitate a 5-day delay, pipelines jointed with rubber gaskets, mechanical or push-on joints, or couplings may be subjected to hydrostatic pressure, inspected, and tested for leakage at any time after **partial** completion of backfill. Cement-mortar lined pipe may be filled with water as recommended by the manufacturer before being subjected to the pressure test and subsequent leakage test.

3.6 LEAKAGE TEST

- 3.6.1 The leakage test shall be conducted after the pressure tests have been satisfactorily completed. The duration of each leakage test shall be at least 2 hours, and during the test the water line shall be subjected to not less than 80 psi pressure. Leakage is defined as the quantity of water to be supplied into the newly laid pipe, or any valved or approved section, necessary to maintain pressure within 1 psi of the specified leakage test pressure after the pipe has been filled with water and the air expelled. Piping installation will not be accepted if leakage exceeds the allowable leakage which is determined by the following formula:

$$L = 0.0001351(N)(D)P^{0.5}$$

L = Allowable leakage in gallons per hour

N = Number of joints in the length of pipeline tested

D = Nominal diameter of the pipe in inches

P = Average test pressure during the leakage test, in psi gauge

Should any test of pipe disclose leakage greater than that calculated by the above formula, the defective joints shall be located and repaired until the leakage is within the specified allowance, without additional cost to the Owner.

The contractor shall be fully responsible for any and all work required to correct any leakage when the leakage test results in water loss that exceeds the amount specified herein.

3.7 EXCAVATION AND BACKFILL

- 3.7.1 All earth excavated from the trench for the pipeline will be considered to be clean and may be used as backfill above the sand bedding.
- 3.7.2 (Changed 6/12/03 to:) Sand bedding shall be imported uncontaminated sand with a maximum of 10% passing the U.S. Standard No. 200 sieve. Compaction of the sand is to consist of 4 to 6 passes with hand compaction equipment (vibrating plate or similar).
- 3.7.3 Initial backfilling shall be accomplished only in sufficient amount to hold the pipeline in place during testing, with the following exceptions:
 - 3.7.3.1 Compacted backfill shall be placed to its final depth as shown on the Drawings at vertical and horizontal deflection points, road crossings, and thrust blocks. Backfill shall be placed such that pipe and joint displacement does not occur.
 - 3.7.3.2 All joints and connections shall be completely exposed for visual observation during testing, except at locations described in the exception above.
- 3.7.4 Backfill above the sand bedding shall be compacted sufficiently so that it will not settle under its own weight.

3.8 SLIPLINING (NOT IN CONTRACT)

After the existing 6-in. sulfuric acid line and its carrier pipe are removed, the 20-in. OD HDPE pipe shall be inserted into the existing 30-in. ID concrete pipe under the levee in accordance with ASTM F 585-94, Standard Practice for Insertion of Flexible Polyethylene Pipe into Existing Sewers.

3.9 GROUT (NOT IN CONTRACT)

The annulus between the 20-in. OD HDPE pipe and the 30-in. ID reinforced concrete pipe shall be grouted with a non-shrink grout under the levee as shown on the drawings. The purpose of the grouting is to seal the annulus such that there will be no seepage path under the levee during a flood event. The grout mix and a detailed grouting procedure

shall be submitted to the Owner for approval. The Contractor's submittal shall discuss the effect of the heat of hydration of the grout on the collapse strength of the HDPE pipe, the effect of expansion and contraction of the pipe during the grouting process, and the pressure exerted on the pipe when the grout is fluid. One grout mix that will be considered satisfactory is the following:

- minimum of 800 pounds of cementitious material to be used per cubic yard of grout
- water to cementitious material (w/c) ratio not exceeding 0.45
- nonshrink agent shall be added to the grout mix in accordance with the manufacturer's recommendations (for example, Sika Intraplast N at a rate of 1 percent by weight of cementitious material)
- chemical admixtures may be used to increase flowability of the grout mixture

During the grouting process the Contractor shall not exceed the allowable grouting pressure of the pipe recommended by the pipe manufacturer, and shall install standpipes or other means to regulate grout pressure in the line. Centering spacers at 90-degree intervals on a 20-ft maximum horizontal spacing shall be used to center the 24-in. OD pipe within the 30-in. ID pipe prior to grouting. Contractor shall submit details of the spacers to the Owner for approval.

3.10 (ADDENDUM 1) FLOWMETER SIGNAL TRANSMISSION TO P-CHEM PLANT

See Drawings 2-15P and -20P. The 4- to 20-ma signal from the flow meter shall be transmitted by wire in 1-in. conduit to the Influent PLC panel at the P-Chem Plant about 1,000 ft west of the pipeline discharge point as shown on the drawings. Below-grade conduit may be HDPE or PVC. All above-ground conduit shall be heavy-wall rigid PVC-coated steel conduit. Coordinate connection of the wire from the flowmeter in this panel with Ron Green, Manager of the P-Chem Plant.

3.11 (ADDENDUM 1) REMOVAL AND REPLACEMENT OF CHAIN-LINK FENCE AT DISCHARGE POINT

A portion of the existing chain link fence at the discharge point shall be removed as required to install the new discharge piping and fittings. When the construction has been

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completed, Contractor shall **replace the fence** and increase the size of the area enclosed as required with matching fence. It is **contemplated** that the eastern and southern sides of the fenced enclosure will remain in **their current location** and the fence shall be extended to the west and north. All new **fence shall match** the existing fence. The 12-ft wide double gate at the northeast corner of the existing enclosure shall be moved as necessary to a similar location in the new **enclosure**. The layout of the new piping and supports may be shifted to minimize the **need to expend** the fenced enclosure if approved by the Owner.

3.12 (ADDENDUM 1) EROSION CONTROL

Contractor shall design, furnish, **install, maintain,** and remove erosion control measures wherever existing vegetation is **removed** or disturbed. Such erosion control shall include but not be limited to silt fences on **the down-gradient side** of all excavations and straw bales across all drainage ditches **and swales**. Remove erosion control measures following completion of seeding and fertilizing **and establishment** of grass cover.

3.13 (ADDENDUM 1) SEEDING AND FERTILIZING

Contractor shall restore the **vegetation in vegetated areas** disturbed by construction by grading, seeding, and fertilizing. Submit plan for this work to Owner for approval.

END OF SECTION

SECTION 02900
SITE RESTORATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Topsoil.
 - 2. Finish grading.
 - 3. Seeding.
 - 4. Fertilizing.
 - 5. Removal of construction wastes.

1.2 SUBMITTALS

- A. Material test reports from qualified independent testing agency indicating and interpreting test results relative to compliance of the following materials with requirements indicated.
 - 1. Topsoil.
 - 2. Seed mixture.
 - 3. Fertilizer analysis.
- B. Materials Source. Submit name, telephone number, and address of imported materials suppliers. Provide location map for source of topsoil.
- C. Provide materials from same source throughout the work. Change of source requires the Owner approval.
- D. Means, methods and location of disposal of construction wastes and general trash.

1.3 DELIVERY, STORAGE AND HANDLING

- A. Storage.
 - 1. Prior to stockpiling topsoil at source for loading and delivery to the Site, treat growing vegetation with application of appropriate specified non-selective herbicide.
 - 2. Treat when foliage is 6 to 10 inches high and approximately 4 to 6 weeks prior to stockpiling.

PART 2 - PRODUCTS

2.1 TOPSOIL MATERIALS

- A. General: Provide approved topsoil from off-site.
- B. Topsoil: ASTM D 5268, fertile, friable, naturally sandy loam, pH range of 5.5 to 7, 4 percent organic material minimum, free of stones 1 inch (25 mm) or larger in any dimension, and other extraneous materials harmful to plant growth. Obtain imported topsoil from naturally well drained sites where topsoil occurs at least 4 inches (100 mm) deep; do not obtain from bogs or marshes.
- C. Tests and sampling of imported topsoil.
 - 1. Sampling by Contractor: Test shall include the following:
 - a. Routine test, plus:
 - b. pH.
 - c. Mineral and plant nutrient content.
 - d. Organic matter.
 - e. Soluble salts.
 - f. Mechanical analysis.
 - g. Report suitability of topsoil for growth of applicable planting material. State recommended quantities of nitrogen, phosphorus, and potash nutrients and any limestone, aluminum sulfate, or other soil amendments to be added to produce a satisfactory topsoil.
 - 2. Do not strip topsoil until source is approved by the Owner.

2.2 SEED

- A. Seed shall be a commercially available mix of Kentucky bluegrass, fescue, perennial and annual rye grasses.

2.3 FERTILIZER

- A. Fertilizer shall be a commercially mix suitable for application where new seed is to be placed.

PART 3 - EXECUTION

3.1 STOCKPILING

- A. Stockpile materials on site where designated by the Owner.
- B. Stockpile in sufficient quantities to meet project schedule and requirements.

- C. Separate differing materials with dividers or stockpile apart to prevent mixing.
- D. Direct surface water away from stockpile site to prevent erosion or deterioration of materials.

3.2 FINISH GRADING

- A. Remove all temporary dams and other temporary structures.
- B. Remove all rubbish and other construction wastes. Haul off site to disposal area approved by the Owner.
- C. Fill all temporary excavations and slurry pits not otherwise filled with material from adjacent pits with topsoil.
- D. Regrade site to March original pre-construction elevations and drainage patterns. Grade site surface to prevent free standing surface water.

3.3 SEED APPLICATION

- A. Apply seed at rates specified by supplier.
- B. Seed shall be applied during growing season unless otherwise approved by the Owner.

3.4 FERTILIZER APPLICATION

- A. Apply fertilizer at rates specified by supplier.

3.5 CONSTRUCTION WASTES AND GENERAL TRASH

- A. Maintain separate disposal areas for construction generated wastes and general trash; including, but not limited to construction material delivery packaging, discarded personal protective equipment and lunchroom type wastes. Do not mix with spoils and other materials generated by barrier wall and other construction.

3.6 STOCKPILE CLEANUP

- A. Remove stockpile, leave area in a clean and neat condition. Grade site surface to prevent free standing surface water.

END OF SECTION

SECTION 02920
CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Galvanized steel chain-link fabric.
 - 2. Galvanized steel framework.

1.2 SUBMITTALS

- A. Product Data: Material descriptions, construction details, dimensions of individual components and profiles, and finishes for the following:
 - 1. Fence and gate posts, rails, and fittings.
 - 2. Chain-link fabric, reinforcements, and attachments.
 - 3. Gates and hardware.
- B. Shop Drawings: Show locations of fence, each gate, posts, rails, and tension wires and details of extended posts, extension arms, gate swing, or other operation, hardware, and accessories. Indicate materials, dimensions, sizes, weights, and finishes of components. Include plans, elevations, sections, gate swing and other required installation and operational clearances, and details of post anchorage and attachment and bracing.
- C. Product Certificates: Signed by manufacturers of chain-link fences and gates certifying that products furnished comply with requirements.
- D. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses.
- E. Field Test Reports: Indicate and interpret test results for compliance of chain-link fence and gate grounding and bonding with performance requirements.

1.3 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who has completed chain-link fences and gates similar in material, design, and extent to those indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
- B. Source Limitations for Chain-Link Fences and Gates: Obtain each color, grade, finish, type, and variety of component for chain-link fences and gates from one source with

resources to provide chain-link fences and gates of consistent quality in appearance and physical properties.

1.4 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify the Owner not less than 7 days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without the Owner's written permission.
- B. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

PART 2 - PRODUCTS

2.1 CHAIN-LINK FENCE FABRIC

- A. Steel Chain-Link Fence Fabric: Height indicated on Drawings. Provide fabric fabricated in one-piece widths for fencing in height of 12 feet and less. Comply with CLFMI's "Product Manual" and with requirements indicated below:
 - 1. Mesh and Wire Size: 2-inch mesh, 0.192-inch diameter.
 - 2. Zinc-Coated Fabric: ASTM A 392, with zinc coating applied to steel wire before weaving according to ASTM A 817, Type II, zinc coated (galvanized)] with the following minimum coating weight:
 - a. Class 2: Not less than 2 oz./sq. ft. of uncoated wire surface.
 - 3. Coat selvage ends of fabric that is metallic coated during the weaving process with manufacturer's standard clear protective coating.
- B. Selvage: Knuckled at both selvages.

2.2 INDUSTRIAL FENCE FRAMING

- A. Round Steel Pipe: Standard weight, Schedule 40, galvanized steel pipe complying with ASTM F 1083. Comply with ASTM F 1043, Material Design Group IA, external and internal coating Type A, consisting of not less than 1.8-oz./sq. ft. zinc; and the following strength and stiffness requirements:
 - 1. Line, End, Corner, and Pull Posts and Top Rail: Per requirements for Light Industrial Fence.
- B. Post Brace Rails: Match top rail for coating and strength and stiffness requirements. Provide brace rail with truss rod assembly for each gate, end, and pull post. Provide two brace rails extending in opposing directions, each with truss rod assembly, for each corner post and for pull posts. Provide rail ends and clamps for attaching rails to posts.

C. Top Rails: Fabricate top rail from lengths 21 feet or longer, with swaged-end or fabricated for expansion-type coupling, forming a continuous rail along top of chain-link fabric.

D. Intermediate Rails: Match top rail for coating and strength and stiffness requirements.

2.3 TENSION WIRE

A. General: Provide horizontal tension wire at the following locations:

1. Location: Extended along bottom of fence fabric.

B. Metallic-Coated Steel Wire: 0.177-inch-diameter, marcelled tension wire complying with ASTM A 824 and the following:

1. Coating: Type II, zinc coated (galvanized) by the hot-dip process, with the following minimum coating weight:

a. Matching chain-link fabric coating weight.

2.4 INDUSTRIAL SWING GATES

A. General: Comply with ASTM F 900 for the following swing-gate types:

1. Single gate.

B. Metal Pipe and Tubing: Galvanized steel. Comply with ASTM F 1083 and ASTM F 1043 for materials and protective coatings.

C. Frames and Bracing: Fabricate members from round galvanized steel tubing with outside dimension and weight according to ASTM F 900 for the following gate fabric height:

1. Gate Fabric Height: 6 feet.

D. Frame Corner Construction: As follows:

1. Welded.

E. Gate Posts: Fabricate members from round galvanized steel pipe with outside dimension and weight according to ASTM F 900.

2.5 FITTINGS

A. General: Provide fittings for a complete fence installation, including special fittings for corners. Comply with ASTM F 626.

B. Post and Line Caps: Hot-dip galvanized pressed steel. Provide weathertight closure cap for each post.

1. Provide line post caps with loop to receive top rail.

- C. Rail and Brace Ends: Hot-dip **galvanized** pressed steel. Provide rail ends or other means for attaching rails securely to each gate, corner, pull, and end post.
- D. Rail Fittings: Provide the following:
 - 1. Top Rail Sleeves: Hot-dip **galvanized** pressed steel. Not less than 6 inches long.
 - 2. Rail Clamps: Hot-dip **galvanized** pressed steel. Provide line and corner boulevard clamps for connecting **intermediate** rails in the fence line to line posts.
- E. Tension and Brace Bands: Hot-dip **galvanized** pressed steel.
- F. Tension Bars: Hot-dip **galvanized** steel, length not less than 2 inches shorter than full height of chain-link fabric. Provide one bar for each gate and end post, and two for each corner and pull post, unless fabric is integrally woven into post.
- G. Truss Rod Assemblies: Hot-dip **galvanized** steel rod and turnbuckle or other means of adjustment.
- H. Tie Wires, Clips, and Fasteners: Provide the following types according to ASTM F 626:
 - 1. Standard Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, complying with the following:
 - a. Hot-Dip **Galvanized Steel**: 0.148-inch-diameter wire; **galvanized** coating thickness matching coating thickness of chain-link fence fabric.
 - 2. Round Wire Hog Rings: Hot-dip **galvanized** steel or aluminum for attaching chain-link fabric to horizontal tension wires.

2.6 FENCE GROUNDING

- A. Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.
 - 1. Material Above Finished Grade: Copper.
 - 2. Material On or Below Finished Grade: Copper.
 - 3. Bonding Jumpers: Braided **copper** tape, 1 inch wide, woven of No. 30 AWG bare copper wire, terminated with **copper** ferrules.
- B. Connectors and Ground Rods: Listed in UL 467.
 - 1. Connectors for Below-Grade Use: Exothermic welded type.
 - 2. Ground Rods: Copper-clad **steel**.
 - a. Size: 5/8 inch by 96 inches.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, **with Installer present**, for compliance with requirements for site clearing, earthwork, pavement work, and other conditions affecting performance.
 - 1. Do not begin installation **before** final grading is completed, unless otherwise permitted by the Owner.
- B. Proceed with installation only **after** unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Stake locations of fence lines, gates, and terminal posts. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

3.3 INSTALLATION, GENERAL

- A. General: Install chain-link fencing to comply with ASTM F 567 and more stringent requirements specified.
- B. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed or compacted soil.
- C. Post Setting: Hand-excavate holes for post foundations in firm, undisturbed or compacted soil. Set terminal, line and gate posts in concrete footing. Protect portion of posts aboveground from concrete splatter. Place concrete around posts and vibrate or tamp for consolidation. Using mechanical devices to set line posts per ASTM F 567 is not permitted. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during placement and finishing operations until concrete is sufficiently cured.
 - 1. Dimensions and Profile: As indicated on Drawings.
 - 2. Exposed Concrete Footings: Extend concrete 2 inches above grade, smooth, and shape to shed water.

3.4 CHAIN-LINK FENCE INSTALLATION

- A. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment.
- B. Line Posts: Space line posts uniformly at 10 feet maximum o.c.
- C. Post Bracing Assemblies: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Install braces at end and gate posts and at both sides of corner and pull posts. Locate horizontal braces at midheight of fabric on fences with

top rail and at two-thirds fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.

- D. Tension Wire: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch-diameter hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches o.c. Install tension wire in locations indicated before stretching fabric.
 - 1. Bottom Tension Wire: Install tension wire within 6 inches of bottom of fabric and tie to each post with not less than same gage and type of wire.
- E. Top Rail: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended by fencing manufacturer.
- F. Intermediate Rails: Install in one piece at post-height center span, spanning between posts, using fittings, special offset fittings, and accessories.
- G. Chain-Link Fabric: Apply fabric to outside of enclosing framework. Leave 2 inches between finish grade or surface and bottom selvage, unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.
- H. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not more than 15 inches o.c.
- I. Tie Wires: Use wire of proper length to firmly secure fabric to line posts and rails. Attach wire at one end to chain-link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain-link fabric per ASTM F 626. Bend ends of wire to minimize hazard to individuals and clothing.
 - 1. Maximum Spacing: Tie fabric to line posts 12 inches o.c. and to braces 24 inches o.c.
- J. Fasteners: Install nuts for tension bands and carriage bolts on the side of the fence opposite the fabric side.

3.5 GATE INSTALLATION

- A. General: Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

3.6 GROUNDING AND BONDING

A. Fence Grounding: Install at **maximum** intervals as follows:

1. Fences within 100 Feet of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet.
 - a. Gates and Other Fence Openings: Ground fence on each side of opening.
 - 1) Bond metal gates to gate posts.
 - 2) Bond across openings, with and without gates, except openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches below finished grade.

B. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet on each side of crossing.

C. Grounding Method: At each grounding location, drive a ground rod vertically until the top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at the grounding location, including the following:

1. Each Barbed Wire Strand. Make grounding connections to barbed wire with wire-to-wire connectors designed for this purpose.
2. Each Barbed Tape Coil: Make grounding connections to barbed tape with connectors designed for this purpose.

D. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.

E. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

F. Bonding to Lightning Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning protection down conductor or lightning protection grounding conductor complying with NFPA 780.

3.7 FIELD QUALITY CONTROL

- A. **Ground-Resistance Testing Agency:** Engage a qualified independent testing agency to perform field quality control testing.
- B. **Ground-Resistance Tests:** Subject completed grounding system to a megger test at each grounding location. Measure ground resistance not less than two full days after last trace of precipitation, without soil having been moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests by two-point method according to IEEE 81.
- C. **Desired Maximum Grounding Resistance Value:** 25 ohms.
- D. **Excessive Ground Resistance:** If resistance to ground exceeds desired value, notify The Owner promptly. Include recommendations to reduce ground resistance and proposal to accomplish recommended work.
- E. **Report:** Prepare test reports, certified by testing agency, of ground resistance at each test location. Include observations of weather and other phenomena that may affect test results.

3.8 ADJUSTING

- A. **Gate:** Adjust gate to operate smoothly, easily, and quietly, free from binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.
- B. **Lubricate hardware and other moving parts.**

3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train the Owner's personnel to adjust, operate, and maintain gates.
 - 1. Test and adjust hardware, and other operable components. Replace damaged or malfunctioning operable components.

END OF SECTION

SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section specifies cast-in place concrete, including formwork, reinforcement, concrete materials, mix design, placement procedures, finishes, curing, and metal anchor requirements for placement in concrete.

1.3 SUBMITTALS

- A. Product Data: For each type of manufactured material and product indicated.
- B. Design Mixes: For each concrete mix. Include alternate mix designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.
 - 1. Indicate amounts of mix water to be withheld for later addition at Project site.
- C. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of current materials:
 - 1. Cementitious materials and aggregates.
 - 2. Form materials and form-release agents.
 - 3. Steel reinforcement and reinforcement accessories.
 - 4. Admixtures.
 - 5. Curing materials.
 - 6. Joint materials.
- D. Steel Reinforcement Shop Drawings: Submit original reinforcement shop drawings, prepared by a registered Professional Engineer in the State of Illinois, for fabrication, bending, and placement of reinforcement for concrete. Comply with ACI 315 "Manual of Standard Practice for Detailing Reinforced Concrete Structures". Include bar schedules; diagrams of bent bars; number, type, spacing

and location of bars within structures; and all information necessary for complete fabrication and placement of all reinforcing steel and bar supports.

1.4 QUALITY ASSURANCE

- A. **Installer Qualifications:** An experienced installer who has completed concrete work similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
- B. **Professional Engineer Qualifications:** A professional engineer who is legally qualified to practice in the State of Illinois and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for reinforcement, formwork and shoring installations that are similar to those indicated for this Project in material, design, and extent.
- C. **Manufacturer Qualifications:** A firm experienced in manufacturing ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.
- D. **Source Limitations:** Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, each aggregate from one source, and each admixture from the same manufacturer.
- E. **ACI Publications:** Comply with the following, unless more stringent provisions are indicated:
 - 1. ACI 301, "Specification for Structural Concrete."
 - 2. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle steel reinforcement to prevent bending and damage.

PART 2 - PRODUCTS

2.1 FORM-FACING MATERIALS

- A. **Rough-Formed Finished Concrete:** Plywood, lumber, metal, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit.
- B. **Form-Release Agent:** Commercially formulated form-release agent that will not bond with or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

1. Formulate form-release agent with rust inhibitor for steel form-facing materials.
- C. Form Ties: Factory-fabricated, removable or snap-off metal or glass-fiber-reinforced plastic form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.
1. Furnish units that will leave no corrodible metal closer than 1 inch to the plane of the exposed concrete surface.
 2. Furnish ties that, when removed, will leave holes not larger than 1/4-in diameter in concrete surface.
- D. Chamfer Strips: Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch minimum.

2.2 STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A 615, Grade 60, deformed.
- B. All reinforcing bars to have lap distance of no less than 54 inches.

2.3 REINFORCEMENT ACCESSORIES

- A. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete or fiber-reinforced concrete of greater compressive strength than concrete.

2.4 CONCRETE MATERIALS

- A. Portland Cement: ASTM C 150, Type II.
1. Fly Ash: ASTM C 618, Class C or F.
- B. Normal-Weight Aggregate: ASTM C 33, uniformly graded, and as follows:
1. Class: Severe weathering region, but not less than 4S.
 2. Nominal Maximum Aggregate Size: 1-1/2 inches.
- C. Water: Potable and complying with ASTM C 94.

2.5 ADMIXTURES

- A. General: Admixtures **certified** by manufacturer to contain not more than 0.1 percent water-soluble **chloride** ions by mass of cementitious material and to be compatible with other **admixtures** and cementitious materials. Do not use admixtures containing calcium chloride.
- B. Air-Entraining Admixture: ASTM C 260.
- C. Water-Reducing Admixture: ASTM C 494, Type A.
- D. Water-Reducing and Accelerating Admixture: ASTM C 494, Type E.
- E. Water-Reducing and Retarding Admixture: ASTM C 494, Type D.

2.6 JOINT MATERIALS

- A. Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber.

2.7 CURING MATERIALS

- A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. dry.
- B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
- C. Water: Potable.

2.8 CONCRETE MIXES

- A. Prepare design mixes for **each type** and strength of concrete determined by either laboratory trial mix or **field test data** bases, as follows:
 - 1. Proportion normal-weight concrete according to ACI 211.1 and ACI 301.
- B. Use a qualified independent **testing** agency for preparing and reporting proposed mix designs for the laboratory **trial mix** basis.
- C. Concrete: Proportion normal-weight concrete mix as follows:
 - 1. Compressive Strength (28 Days): 4000 psi unless noted otherwise on the drawings.
 - 2. Maximum Slump: 4 inches.

3. **Maximum Water-Cementitious Materials Ratio:** 0.40 for corrosion protection of steel reinforcement in concrete exposed to chlorides from deicing chemicals or salt, saltwater, or brackish water.
- D. **Cementitious Materials:** Limit percentage, by weight, of cementitious materials other than Portland cement in concrete as follows:
 1. Fly Ash: 25 percent.
- E. **Air Content:** Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having an air content as follows within a tolerance of plus or minus 1.5 percent:
 1. Air Content: 5.5 percent for 1-1/2-inch nominal maximum aggregate size.
- F. **Limit water-soluble, chloride-ion content** in hardened concrete to 0.15 percent by weight of cement.
- G. **Admixtures:** Use admixtures according to manufacturer's written instructions.
 1. Use water-reducing admixture in concrete, as required, for placement and workability.
 2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
 3. Use water-reducing admixture in pumped concrete and concrete with a water-cementitious materials ratio below 0.50.

2.9 FABRICATING REINFORCEMENT

- A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.10 CONCRETE MIXING

- A. **Ready-Mixed Concrete:** Measure, batch, mix, and deliver concrete according to ASTM C 94, and furnish batch ticket information.
 1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.1 FORMWORK

- A. Design, erect, brace, and **maintain** formwork, according to ACI 301, to support vertical, lateral, static, and **dynamic** loads, and construction loads that might be applied, until concrete **structure** can support such loads.
- B. Construct formwork so **concrete** is of size, shape, alignment, elevation, and position indicated in Drawings, **within tolerance** limits of ACI 117.
- C. Limit concrete surface **irregularities**, designated by ACI 347R as abrupt or gradual, as follows:
 - 1. Class B, 1/4 inch.
- D. Construct forms **tight enough** to **prevent** loss of concrete mortar.
- E. Fabricate forms for **easy removal** without hammering or prying against concrete surfaces.
- F. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and **slopes** in finished concrete surfaces. Provide and secure units to support screed strips; **use** strike-off templates or compacting-type screeds.
- G. Chamfer exterior corners and **edges** of permanently exposed concrete.
- G. Clean forms and adjacent **surfaces** to receive concrete. Remove chips, wood, sawdust, dirt, and other debris **just before** placing concrete.
- H. Retighten forms and bracing **before** placing concrete, as required, to prevent mortar leaks and maintain proper **alignment**.
- I. Coat contact surfaces of forms **with** form-release agent, according to manufacturer's written instructions, **before placing** reinforcement.

3.2 REMOVING AND REUSING FORMS

- A. Formwork may be removed **after** cumulatively curing at not less than 50 deg F for 24 hours after placing concrete **provided** concrete is hard enough to not be damaged by form-removal operations and **provided** curing and protection operations are maintained.
- B. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise **damaged** form-facing material will not be acceptable. Apply new form-release agent.

3.3 STEEL REINFORCEMENT

- A. General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials.
- C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.
- D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

3.4 JOINTS

- A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.
 - 1. Place joints as shown on project drawings. Do not continue reinforcement across construction joints.

3.5 CONCRETE PLACEMENT

- A. Before placing concrete, verify that installation of formwork and reinforcement is complete and that required inspections have been performed.
- B. Before placing concrete, water may be added at Project site, subject to limitations of ACI 301.
- C. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.
 - 1. Consolidate concrete during placement operations so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
 - 2. Maintain reinforcement in position on chairs during concrete placement.
 - 3. Screed slab surfaces with a straightedge and strike off to correct elevations.
 - 4. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, free of humps or hollows, before excess moisture or bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.

- D. **Cold-Weather Placement:** Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
1. When air temperature **has** fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of **not less than 50 deg F** and not more than 80 deg F at point of placement.
 2. Do not use frozen **materials** or materials containing ice or snow. Do not place concrete on frozen **subgrade** or on subgrade containing frozen materials.
 3. Do not use calcium **chloride**, salt, or other materials containing antifreeze agents or chemical **accelerators**, unless otherwise specified and approved in mix designs.
- E. **Hot-Weather Placement:** Place concrete according to recommendations in ACI 305R and as follows, **when hot-weather conditions exist:**
1. Cool ingredients **before mixing** to maintain concrete temperature below 90 deg F at time of **placement**. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of **mixing water**. Using liquid nitrogen to cool concrete is Contractor's option.
 2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient **air temperature** immediately before embedding in concrete.
 3. Fog-spray forms, **steel reinforcement**, and subgrade just before placing concrete. Keep **subgrade** moisture uniform without standing water, soft spots, or dry areas.

3.6 FINISHING FLOORS AND SLABS

- A. **General:** Comply with **recommendations** in ACI 302.1R for screening, restraighening, and **finishing operations** for concrete surfaces. Do not wet concrete surfaces.
- B. **Broom Finish:** Apply a broom finish to slabs.
1. Immediately after **float finishing**, slightly roughen surface by brooming with fiber-bristle broom.

3.6 CONCRETE PROTECTION AND CURING

- A. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and with recommendations in ACI 305R for hot-weather protection during curing.
- B. Formed Surfaces: Cure formed concrete surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing by one or a combination of the methods outlined for unformed surfaces:
- C. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces by one or a combination of the following methods:
 - 1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
 - a. Water.
 - b. Continuous water-fog spray.
 - c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.
 - 2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: The Owner will engage a qualified independent testing and inspecting agency to sample materials, perform tests, and submit test reports during concrete placement. Sampling and testing for quality control may include those specified in this Article.
- B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:
 - 1. Testing Frequency: Obtain at least one composite sample for each 50 cu. yd. or fraction thereof of each concrete mix placed each day.
 - 2. Slump: ASTM C 143; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mix. Perform additional tests when concrete consistency appears to change.

3. Air Content: ASTM C 231, pressure method, for normal-weight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mix.
 5. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each composite sample.
 6. Compression Test Specimens: ASTM C 31; cast and laboratory cure one set of four standard cylinder specimens for each composite sample.
 7. Compressive-Strength Tests: ASTM C 39; test one laboratory-cured specimens at 7 days and two at 28 days. One specimen is to be laboratory-cured, held, and tested if necessary at the direction of the Owner.
 - a. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at age indicated.
- C. Strength of each concrete mix will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.
- D. Test results shall be reported in writing to the Owner, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7-and 28-day tests.
- E. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, or other requirements have not been met, as directed by Engineer.

3.8 EMBEDDED ITEMS

- A. Place and secure anchors as shown on project drawings. Anchors are to be installed in accordance with manufacture's instructions, diagrams, and directions furnished with anchors. Anchors are designed to be installed in cured concrete.

END OF SECTION

SECTION 13500

PIEZOMETERS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. This section covers **furnishing** and installing temporary and permanent piezometers, including **both** open standpipe and vibrating wire, to monitor groundwater. This section also includes the terminal apparatus and portable readout devices required for **manual** operation of the instruments.

1.2 REFERENCE STANDARDS

- A. ASTM C 33: **Specification** for Concrete Aggregates
- B. ASTM D 1586: **Test Method** for Penetration Test and Split-Barrel Sampling of Soils
- C. ASTM D2487: **Classification** of Soils for Engineering Purposes

1.3 SUBMITTALS

- A. Submit a plan showing **the** proposed drilling and installation equipment and methods.
- B. Submit manufacturer's **product** data for approval at least 10 days before delivery to the site.
- C. As-Built Drawings – **Within** five (5) workdays of installing each piezometer, submit As-Built Drawings **showing** the exact installed location, the instrument type and identification **number** (if applicable), and the installation date and time. Accurately record **top elevation** and as-built geometry of each piezometer following installation **and prepare** a boring log at each piezometer location using a drill rig to obtain the **proper** depth. Include details of installed piezometers, instrument calibrations, **accessories** and protective measures including all dimensions and **materials used**. Amend project drawings during construction to reflect changes in **piezometer** installations, as approved by the Owner.
- D. **Operation and Maintenance Manuals** for all equipment (two copies each).

- E. **Manufacturer's warranty for all vibrating wire piezometers and readout units within two (2) workdays of receipt of the instrument.**

1.4 DELIVERY, HANDLING, STORAGE, AND MAINTENANCE

- A. **All materials shall arrive at the site undamaged and shall be stored indoors, in a clean, dry, and secure area. Instruments shall not be exposed to temperatures outside the manufacturer's stated working temperature range. Any instruments or materials damaged by mishandling will be rejected by the Owner for use and shall be replaced at the Contractor's expense.**
- B. **Maintain all instrumentation installations in progress and all completed instrumentation installations. Immediately repair or replace, as deemed necessary by the Owner, any damage to installations in progress, or installations completed.**

PART 2 PRODUCTS

2.1 MATERIALS

- A. **Covers - Provide covers for piezometers as shown on the Drawings.**
- B. **Piezometer Backfill Sand: Conform with ASTM C 33 specification for fine aggregates with a maximum of 5 percent passing the 200 sieve.**
- C. **Piezometer Backfill Bentonite: Bentonite pellets shall have ½-inch diameter and a dry bulk density of 82 pounds per cubic foot, such as Bentonite-Pi pellets manufactured by Piezometer Research and Development Corporation or approved equal.**

2.2 EQUIPMENT

- A. **Where model numbers are given in this section, they shall be understood to represent models selected on the basis of past factory specifications and project experience demonstrating that the equipment, including stipulations herein, would meet the performance objectives of this Work. Verify with any selected manufacturer that the designated model, or the updated version, meets the design performance outlined by these drawings and specifications. The detailed working drawings and manufacturer's technical specifications submitted in accordance with the drawings and specifications for this Contract shall comprise the criteria for equipment or materials approval.**

- B. **Water Level Indicator – Model 51690030 Water Level Indicator** (100 ft length cable), as manufactured by SINCO, Seattle, WA, or approved equal.
- C. **Permanent Piezometer Casing – Connecting 2-inch diameter, Schedule 40 stainless steel slotted screen (10 slot), and 2-inch diameter, Schedule 40 stainless steel riser pipe.**
- D. **Temporary Piezometer Casing – Connecting 1-inch diameter, Schedule 40 PVC slotted screen (10 slot), and 1-inch diameter, Schedule 40 PVC riser pipe.**
- E. **Vibrating Wire Piezometers – as specified in Section 16900.**
- F. **Bollards – 7-foot long, 6-inch diameter standard weight steel pipe.**

2.3 FABRICATION

Piezometers, Electric Vibrating Wire Type - Factory-calibration curves are required for each piezometer, including individual gage factor, temperature correction factor, and barometric pressure at time of calibration. The gages shall be fabricated and tested by the manufacturer. No on-site fabrication shall be allowed.

PART 3 EXECUTION

3.1 PREPARATION

- A. **Verify that all drill holes have been drilled to the correct size, depth and orientation prior to installation of instruments.**
- B. **Protection - Protect structures and facilities during drilling of the piezometer holes.**

3.2 INSTALLATION

- A. **Furnish all labor, equipment, materials, power supplies and incidentals required to install a complete, fully functional, ready-for-operation instrumentation (control and monitoring) system as specified and shown on the Drawings.**
- B. **Operation and field calibration checks of all instruments shall be demonstrated by the Contractor and witnessed by the Owner shortly before instruments are transported to the installation location.**

- C. Cables for the piezometers shall be direct bury cable. Five percent extra cable length shall be assumed to allow for deflections after installation.
- D. Install piezometers using the following procedures:
 - 1. Advanced borings by means of a rotary tri-cone, coring bit, or hollow-stem auger. If necessary, use a casing to prevent sloughing and maintain an open borehole. The use of drilling mud with bentonite to maintain the hole open shall not be permitted. The use of revert will be allowed in drilling mud. Use clean, fresh water as a drilling fluid to clean out the borehole prior to piezometer installation.
 - 2. Drill borehole within one degree of vertical. The borehole shall be approximately 6-inches in diameter and shall be drilled to approximately 1 ft below the installation depth shown on the Drawings. Dispose of soil cuttings and drilling fluids in the temporary spoil stockpile after solidification. Dispose oil and grease waste, and all other waste in accordance with applicable federal and state regulations, and in locations approved by the Owner.
 - 3. Obtain split-spoon samples (ASTM D1586) at 5-foot intervals in soil. Classify soils using the Unified Soil Classification System (ASTM D2487).
 - 4. Prepare a boring log to document the soil conditions at the piezometer locations. The log shall be prepared by a geologist or geotechnical engineer under the supervision of a registered professional engineer.
 - 5. Install casing as shown on the Drawings. Use stainless steel slotted screen and riser for permanent piezometers, and PVC slotted screen and riser for temporary piezometers. Top and bottom end caps are required. Permanent and temporary piezometer locations are identified on the Drawings.
 - 6. Backfill to 2-feet above screened zone using approved backfill sand pack as shown in Drawings. Install 2-foot thick bentonite seal using approved bentonite pellets. Backfill to ground surface using approved cement grout.
 - 7. Upon completion of the installation, the instrument shall be tested in accordance with recommendations of the manufacturer.

Submittal 7/03/03

8. Construct casing cover and bollard protection for piezometers as shown on the Drawings.

END OF SECTION

SECTION 16500

ELECTRICAL POWER SUPPLY MATERIALS AND METHODS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

- A. This Section and accompanying drawings are intended to cover the provision of all labor, material, and equipment necessary for the required electrical work for the installation of the Groundwater Migration Control System (GMCS) as shown on the Drawings and as described herein and in other Sections of these Specifications. This Section describes the minimum requirements for the Contractor to provide all labor, materials, and equipment for the following:
 - 1. Provide and install all electrical components, including all arrangements (installation costs, fees, applications, etc.) to provide a new 480-volt, 3-phase electrical service at the Pole Barn on the site for use at the extraction wells.
 - 2. Provide and install all power and control wiring and conduit for the new extraction wells and Automated Control and Monitoring System (ACMS) as shown on the drawings.
- B. Furnish and install all appurtenances and elements for complete functioning systems, whether or not specifically indicated in the Contract Documents. Provide services and equipment as specified in the Contract Documents.
- C. All electrical splices and devices located at an elevation below the 100-year flood (EL 426 NGVD) shall be rated for NEMA 6P (submersible).

1.2 CODES AND REGULATIONS

- A. Comply with the latest editions of the following authorities, including all supplements thereto, and any other authority having jurisdiction within the requirements of this Section.
 - 1. Local Codes
 - 2. National Electrical Code (NEC) as amended (NFPA No. 70, 71, 72, 72C)
 - 3. Occupational Safety and Health Association (OSHA)
 - 4. Building Officials and Code Administration International (BOCA) Code.
 - 5. National Fire Protection Association (NFPA)
 - 6. Underwriter's Laboratories (UL)
 - 7. Factory Mutual (FM)
- B. Whenever the Contract Documents require materials, workmanship, arrangement, or construction of higher standard or larger size than is required by the codes and regulations, the Contract Documents shall take precedence.

- C. Should there be direct conflict between any codes, ordinances, rules, regulations, and laws, as specified above, and the Contract Documents, the applicable code, ordinance, rule, regulation, or law shall govern.
- D. All electrical materials and equipment shall bear the label of Underwriter's Laboratories; listed by them in their list of electrical fittings; and approved by them for purpose for which the material or equipment is to be used, unless the material or equipment is of type for which Underwriter's Laboratories do not list or provide label service.
- E. All electrical connectors and conductors shall be copper

1.3 SUBMITTALS

- A. The Contractor shall submit the following information, tabulated in booklet form, for each piece of equipment or system furnished under this Section.
- B. Shop Drawings:
 - 1. Submit a detailed layout showing the location of electrical components and routing of conduit and wiring.
- C. Product Data:
 - 1. Submit supplier's product data for all electrical components including:
 - a. Wire, conduit and associated fittings;
 - b. All control components with control wiring diagrams; and,
 - c. Disconnect switches.
- D. Technical Manual (O&M Manual):
 - 1. Include record copies of the Shop Drawings.
 - 2. Provide the supplier's installation and Operation and Maintenance Manuals for each electrical component.

PART 2 PRODUCTS

2.1 CONDUIT AND FITTINGS

- A. All underground conduits and fittings shall be rigid nonmetallic, approved for direct burial. Underground conduit and fittings for control wire may be Schedule 40 PVC or, if under a roadway, Schedule 80 PVC.
- B. Above ground conduits and fittings shall be galvanized rigid steel, including all upturned elbows and conduits passing through masonry and/or the ground surface.
- C. Use only hot-dip galvanized fittings, for elbows, unions, receptacle and switch boxes; type FS or FD, manufactured by Appleton, Crouse-Hinds, O.Z. Electric, Thomas & Betts, or favorably approved equivalent.
- D. All conduit, fittings, and connections shall be watertight.
- E. Conduit entrances shall be through the bottom or sides of enclosures.

2.2 JOINING AND SEALING OF CONDUIT

- A. Effectively seal all threaded joints in conduit and couplings, using code approved pipe thread compound or red lead applied to male thread only, with joint butted properly within coupling.
- B. Install conduit with fittings, boxes, etc. of the type required and in the manner required to prevent intrusion of moisture. Seal all terminal ends of service conduits and bushings with favorably reviewed insulating sealing compound.

2.3 JUNCTION AND PULL BOXES

- A. Where required for proper execution of the Work, provide all junction and/or pull boxes, each of proper size, and type for location and use, complete with screw covers of size convenient and adequate for proper installation of required number of cable and wires; to conform with code requirements. Provide adequate pull boxes for future pulling and removal of wires.

2.4 WIRE

- A. 600V Cable:
 - 1. All 480 volt power wiring shall be metal clad Type CLX XHHW-2, approved for direct burial.
 - 2. All 120/240 volt wiring shall be stranded copper with XHHW insulation. Multi-conductor cables shall have a PVC jacket.
 - 3. All wiring shall be copper, having 600-volt insulation. Aluminum wire shall not be allowed.

4. Wire Manufacturer: **Belden**, or favorably reviewed equal.
- B. Instrumentation Cable:
1. Conductor size shall be as provided by the manufacturer.
- C. Execution:
1. Identify all main feeders and branch circuits by color-coded wire as required by Code.
 2. Do not use block and tackle or other mechanical means of pulling wire through conduit. All wire or cables pulled in conduit or duct shall be pulled with a pulling compound favorably reviewed by the Owner.
 3. On all circuit wiring throughout, allow sufficient slack at splices and outlets to permit connections without straining generally not less than 6 inches in junction or outlet boxes and 10 inches in ducts, troughs or pull boxes.
 4. Splicing Terminal and Tap Connections: Make joints and splices only in pull boxes, junction boxes, and outlet boxes in mechanically and electrically secure manner using only approved solderless connectors, lugs, and as approved by Code.
 5. Make all terminal connections of mains and feeder circuits using approved high pressure clamping type solderless connectors.
 6. Make all branch circuit terminal connections and splices using only 3M Scotchlok electrical spring connectors and insulate with Scotch or other approved plastic electrical tape, or by using nylon "Wing Nut Connectors" with internal spring tension grip insulated with favorably approved plastic electrical tape.
 7. Ordinary wire nuts or porcelain type connectors are not acceptable.
 8. Properly identify and tag all mains, feeders, and branch circuits in all pull boxes, gutters, troughs, junction boxes, and other areas in which they connect. Similarly, identify and tag wires where two or more circuits run to or pass through same outlet or junction box.
 9. Install tags in all pull boxes, troughs, junction and outlet boxes, and in gutter of all panels, as wires are pulled.
 10. All tags: Flame resistant linen, wired on, marked in indelible ink; in each case, bearing designation of feeder or circuit.
 11. Uninsulated conductors shall be bare type ACSR.
 12. All control wire shall be in separate conduit then power distribution wiring.

2.6 GROUNDING

- A. Grounding and bonding **shall** be in accordance with the NEC and with the requirements of the governing utility. All exposed non-current carrying metallic parts of the electrical equipment, **metallic** raceway systems and neutral conductor of wiring systems shall include **grounds driven** into ground. Ground rods shall be high-strength steel core, copper clad, **5/8-inch diameter** by 10 feet length. Rods shall be UL listed and driven to 2 foot below **grade**. All grounding conductors shall be of copper.
- B. Adequately ground all **isolated conduit** systems for low tension work.
- C. Provide the Owner with **test results** that demonstrate that the resistance to ground for the grounding system is not **more than** 15 ohms.

2.7 NAMEPLATES

- A. Provide nameplates for **all control** equipment or engraved laminoid; riveted in place. Nameplates **shall be** one inch high with $\frac{1}{2}$ " lettering of total length equaling length of lettering **plus** $\frac{1}{2}$ " each side.

2.8 DISCONNECT SWITCHES

- A. Provide fusible disconnect **switch**, where indicated on the Drawings. They shall be NEMA 4X outdoors.
- B. Type: Heavy duty switch **sized** for load serviced; non-fusible where used purely as disconnect device. **Provide** the proper number of poles and a solid neutral where required.
- C. Fuses: Where fused **switches** are required and where the fuse type is not indicated on the drawings, provide **Type FRS** fuses for 480 volt systems.
- D. Shall be rated 480 VAC.

2.9 FLEXIBLE METAL CONDUIT AND FITTINGS

- A. Oil and moisture tight **galvanized** steel flexible conduit with copper bonding conductor and synthetic **rubber** jacket; "Sealtight" as manufactured by American Brass Co., or favorably **reviewed** equal, complete with ground bushings.
- B. Fittings: Appleton Series "AT" fitters, unions, elbows, gaskets and locknuts, or favorably reviewed equal.

2.10 OUTLET BOXES

- A. Except as otherwise **specified**, provide stamped steel boxes of proper size gauge and type for each location and use; securely fastened in place not supported by conduit. Exposed boxes **shall** be cast FS or FD type. Provide fixture studs in boxes, where required.
- B. Manufacturers: Appleton, Crouse-Hinds, Steel City, Rayco or J.R. Richards.

2.11 SPARE PARTS

- A. The Contractor shall **provide the** following spare parts:
 - 1. Two (2) sets of **fuses** for each type and size of fuse required.

PART 3 EXECUTION

3.1 WORK BY CONTRACTOR

- A. Furnish and install new **fused** disconnect switches in the existing Pole Barn.
- B. Conduit and wiring from **the** Pole Barn shall be routed in overhead conduit out of the building. Outside of **the** building, the wiring shall be routed below ground to the control panels at each well.
- C. Conduit and wiring from **each** control panel to the individual extraction pumps shall be routed below **ground** as shown on drawings.

3.2 QUALITY ASSURANCE/QUALITY CONTROL

- A. Prior to the turning over of work as complete unit, test all wiring installed under this contract for proper **connections**, short circuits and grounds. Conduct tests with the aid of suitable **testing** instruments in the presence of, and submit results to the Owner.
- B. All work must be **completed** to the satisfaction of the Owner.

END OF SECTION

SECTION 16900

AUTOMATED CONTROL AND MONITORING SYSTEM (ACMS)

PART 1 GENERAL

1.1 SCOPE

- A. This section includes performance based technical specifications for the Automated Control and Monitoring System (ACMS). The ACMS is a key component of the Groundwater Migration Control System (GMCS). The primary function of the ACMS will be to monitor stage level of the Mississippi River and automatically adjust pumping rates of the three extraction wells. A secondary function of the ACMS will be to monitor the water level in four pairs of piezometers, which will be equally spaced along the west barrier wall. One piezometer of each pair will be located inside the barrier wall and one will be located outside the wall. The piezometers will be used to monitor groundwater gradients across the barrier wall. Drawing 6-1 shows a plan view of the extraction wells and the automated piezometers in relation to the proposed barrier wall and the Mississippi River.

The ACMS will consist of the following key components:

- Measurement and Control Unit (MCU)
- Automated River Stage Gage
- Power distribution panel
- Pump control panels w/variable frequency drives
- Magnetic flow meters at each extraction well
- Automated piezometer pairs along west barrier wall
- Host/Remote Access PC

The contractor shall be responsible for installing the ACMS described in this document.

- B. Requirements include; on-site calibration, project specific operations manual, conducting on-site personnel training and final system acceptance testing for approval by the Owner.
- C. Provide one-year maintenance of the ACMS and related instrumentation following final system acceptance by the Owner.
- D. All system hardware, software and services, necessary to make the ACMS complete and fully operational, but not expressly specified, shall be provided by the Contractor.

1.2 RELATED SECTIONS

- A. Section 02920 – Chain Link Fencing
- B. Section 02700 – Piezometer Installation
- C. Section 02550 – Effluent Pipeline and Appurtenances
- D. Section 02260 – Trenching and Backfilling
- E. Section 16500 – Electrical Power Supply

1.3 REFERENCE STANDARDS

- A. National Electrical Manufacturers Association (NEMA).
- B. American National Standards Institute (ANSI) - 37.90a.
- C. Electronic Industries Association (EIA).
- D. National Electrical Safety Code (ANSI/IEEE)
- E. National Electrical Code (N70 –1999)

1.4 SUBMITTALS

- A. Submit shop drawings and product data sheets for all components of the ACMS. Final shop drawings are to be approved by the Designer before work can commence.
- B. Prior to commencing ACMS installation the Contractor shall provide a description of proposed installation procedures for review by the Owner. This installation plan shall address construction sequencing, cable pulling plans, diagrams, instructions, and precautions required to install, adjust, and calibrate system components.
- C. The contractor is responsible for submitting a separate programming manual containing all of the programming provided for the ACMS system as specified in later sections of this document including the programming of the measurement and control unit (MCU). The programming manual shall be updated as changes are made during the one-year warranty period.
- D. The contractor shall prepare an ACMS Acceptance Test Plan for review by the Owner. Once approved, the Acceptance Test Plan will be used to verify that all ACMS functions perform properly.

- E. The Contractor shall prepare a detailed, project specific, operations and maintenance manual (O&M) Manual. The O&M Manual shall include the following information:
- Wiring diagrams, control diagrams, and control sequence for the ACMS and items of equipment,
 - Start-up, proper adjustment, operating, and shutdown procedures,
 - Safety Precautions,
 - Procedures in the event of equipment failure, and
 - Other items of instruction as recommended by the manufacturer of each system component.
- F. The contractor is responsible for submitting five sets of final manuals and drawings of the "as built" ACMS. Also provide an electronic copy of manuals in Word 2000 format and drawings in AutoCAD V14 format on CD-ROM. Electronic files include data sheets for each component which shall reference the manufacturer's web site, a list of components with the phone number and/or web site of each component manufacturer, installation instructions and manuals supplied with the equipment purchased, and drawings used to fabricate parts referenced in the drawings.

PART 2 PRODUCTS

2.1 DESCRIPTION

- A. Measurement and Control Unit (MCU) - The ACMS MCU equipment shall be Geomation Series 2380 Measurement and Control Units manufactured by Geomation, Golden, Colorado 80401, phone number (720) 746-0100.
- B. The following key components will be required to construct the ACMS.
1. Vibrating Wire Pressure Transducers - The open-standpipe piezometer pairs will be automated using Geokon 4500S vibrating wire pressure transducers with built-in surge protection. The pressure range of each sensor is 0-50 psi. The sensors shall be non-vented and use Stainless Steel 316 components with stainless steel sheath on the cable.
 2. River Stage Gage - The River Stage Gage (RS-1) is an existing bubbler-type water level indicator owned and operated by the American Bottoms Regional Wastewater Treatment Facility (ABRWTF). The contractor will make necessary contacts and coordinate with ABRWTF to connect to the existing gage terminal block located at the northwest corner of Site R. Output signals from the gage will be 4-20ma.

3. **Magnetic Flow Meters** – The flow rate at each extraction well shall be monitored using Krohne – Aquaflux Electromagnetic Flow Meters with remote 020F digital LCD readout or approved equivalent. The flow meters shall output a 4-20ma signal with an operating range of 0-400 gpm. The cable shall be potted at the flow meter and rated for submerged operation (NEMA 6). The readout unit shall be installed in the pump control panel enclosure at each well. The flow meter shall be installed inside the flow meter/sampling vault as shown on the drawings.
4. **Barometer** – Barometric pressure corrections will be required for each of the non-vented vibrating wire pressure transducers. The barometer shall be a Met One Model 091 or approved equivalent. The barometer shall be installed in the MCU enclosure to be located inside the existing pole barn.
5. **Power Distribution Panel** – There will be a new power distribution panel located inside the southeast corner of the existing pole barn. The power distribution panel will be sized to accommodate power connections for the three extraction well pumps and disconnects. There will also be one 120VAC, 1-Phase individual branch circuit to operate the MCU. All of the wiring from the power distribution panel to the three extraction wells will be in buried conduit. All power cables, running from the power distribution panel to the extraction wells, shall be Belden shielded power cable rated for direct burial. Care shall be taken to ensure that power cables are separated by at least 2 ft from all signal cables except for right angle crossings where necessary. All power for the variable frequency drives (VFDs) and the pump motors will be 480VAC, 60HZ, 3-Phase. There will also be a separate breaker and a separate 120VAC circuit installed at each extraction well location area.

Contractor shall refer to Section 16500 – Electrical Power Supply for details associated with all ACMS electrical power supply requirements.

6. **Pump Control Panel and Variable Frequency Drives** - A pump control panel/enclosure shall be located at each extraction well pad. Each control panel enclosure shall consist of a NEMA 4 power ventilated enclosure that contains a variable frequency drive (VFD) for the pump motors. The control panel enclosure shall also house the flow meter LCD readout and interface unit. A manual pump control panel will be used to operate the pumps directly in VFD by-pass mode, and to power a light in the flow meter vault. The pump control panel/enclosure will also contain 480VAC, 3-Phase power, 120VAC, 1-Phase power for the flow meter, two 120VAC duplex outlets, and pass through wiring for the vibrating wire piezometer monitoring water level in each well.

A Reliance electric SP600 variable frequency AC drive (VFD), or approved equivalent, will operate each pump motor. The VFD will allow variable speed operation of the pump motor and allow a variable pumping flow rate to be

achieved by each pump. By using a flow meter at each well, the flow meter's 4-20 ma output will provide a feedback signal to the MCU to allow closed-loop operation of the pumps. This will allow the VFD to maintain the flow (gpm) set point provided by the MCU for a given river stage elevation. Each VFD will provide switch closure signals to the MCU to indicate fault conditions and accept 4-20ma signals to control the speed and starting/stopping of the pump motors.

7. Automated Phone Dialer – An automated phone dialer shall be located in the MCU enclosure to accept inputs from the MCU indicating fault conditions (e.g., pump failure, VFD faults, water levels, etc). The Sensaphone 2000 manufactured by Phonetics Inc. Aston PA 19014, 610-558-2700 or an approved equivalent shall be used.
- C. The ACMS Host/Remote Access PC will serve as host to the on-site MCU for remote users. Necessary hardware and software specifications are presented in the following sections.
- D. In addition to the key ACMS components listed above there are various signal and power cables, surge protection modules, conduit, junction boxes, and pull-boxes required. Details associated with these components of the system are included in the following sections.
- E. ACMS Installation Contractor - Company specializing in installing and configuring the specified ACMS equipment for applications of this type with minimum of 10-years of experience.

2.2 GENERAL SYSTEM REQUIREMENTS

- A. The three extraction well pumping rates will primarily be a function of river stage. Table 6-1 shows the calculated combined pumping rates for the three wells based on river stage. As shown on Table 6-1 the calculated combined pump flow rates range from 0 to 950 gpm for a corresponding river stage range of 413 ft to 374 ft, (amsl). For reference purposes the 100-year flood stage at Site R is about 426 ft, (amsl).

When Mississippi River stage reaches elevation 413 ft, amsl and above the pumping system will automatically shutdown. The system will automatically restart pumping once the river level falls below 413 ft, amsl.

Occasionally it may be necessary to temporarily increase extraction well pumping rates to maintain a "zero" gradient across the barrier wall. As mentioned above, water levels in the four pairs of piezometers, along the west wall of the proposed barrier wall, will be read automatically. If the average water level inside the barrier wall is greater than the average water level outside the barrier wall for a period of

one to two days the extraction well pumping rates will be increased until a "zero" gradient condition is reestablished across the wall.

The ACMS will employ **variable** frequency drives (VFDs) on each of the extraction well pump motors. The VFDs will provide the ability to optimize overall performance of the GMCS **resulting** in reduced energy and extracted groundwater treatment costs. The VFDs will be controlled by the MCU.

2.3 VIBRATING WIRE PIEZOMETERS (OPEN-STANDPIPE PIEZOMETERS)

- A. Open-standpipe piezometer **transducers** shall use vibrating wire technology with built-in surge protection. **Geokon Model 4500S**, 0-50 psi, with stainless steel housing, non-vented **transducer** shall be used.
- B. All vibrating wire **transducers** shall have a factory-installed cable without splices that will connect to the **Geokon LAB3** surge protection module located near the top of the standpipe in a **NEMA 6 enclosure**.
- C. Wiring for the piezometers **shall be** accomplished by the following method:
 - 1. Using the cable **supplied by the sensor manufacturer**, wire the transducer to the lightning protection device located near the piezometer location.
 - 2. Use **Anixter E-000622DFC cable** or approved equivalent (see drawings); signal cable from the lightning protection device to the junction box located between each piezometer pair.
 - 3. At the junction box **combine** two piezometer cables for each pair into one cable and continue via buried **conduit** directly to the MCU. The shields for each wire shall also be connected. **No splices** are permitted from the respective piezometer pair junction box to the MCU at the pole barn.
 - 4. The contractor shall **record the signal cable color scheme** used and submit that as part of the final project documentation and as-built drawings.
- D. Special care shall be **taken to appropriately ground** individual vibrating wire transducers and the **Geokon LAB3** surge protection modules. Suitable grounding shall be provided at each **open-standpipe** location.
- E. Ground Test - Test each ground rod installation by performing a Fall-of- Potential test using a **Biddle Digital Earth Tester Model 5/2** or approved equivalent.
 - 1. Record results of each ground rod test.

2. Each measured ground rod shall have measured resistance to ground of 5 ohms or less. When the required ground resistance is not met, additional ground rods shall be provided interconnected with grounding conductors to achieve the 5-ohm ground resistance.
3. The Designer, before the completion of the project, shall approve all grounding measurements.

2.4 RIVER STAGE GAGE

- A. American Bottoms Regional Wastewater Treatment Facility (ABRWTF) maintains a bubbler-type gage at their outfall pipe to the Mississippi River immediately north of Site R. ABRWTF currently obtains automated river stage readings via a telephone line connection to the bubbler gage readout unit located near the existing catwalk. Contractor shall contact and coordinate with ABRWTF to share the output signal of the bubbler gage. A 4-20ma output signal can be obtained by direct connection to the existing terminal block and connecting to the MCU via buried conduit.
- B. All wiring for the river stage gage shall be without splice until the surge protection device located at the MCU.

2.5 ELECTROMAGNETIC FLOW METERS

- A. Three extraction well flow meters will use electromagnetic flow measurement technology.
- B. Flow meters shall be mounted in the flow meter/sampling vault at each extraction well and the signal converter and LCD readout unit shall be located in the pump control/VFD enclosure at each well.
- C. The flow meters shall output 4-20ma signal levels with a corresponding operating range of 0 to 400 gpm and an accuracy of 0.25% full-scale. The flow meters shall be temperature compensated.
 1. They shall operate with a power input of 120VAC.
 2. The sensor output shall be 4-20ma using a powered current loop from the MCU with 600-ohm maximum total loop resistance.
 3. Zero flow or an empty pipe shall give a stable 4ma signal.
- D. Each flow meter signal converter and readout unit shall be mounted in the pump control panel/enclosure.

- E. Power for the flow meters shall be from a 120VAC source located at the pump control panel. This power source does not require battery backup, however, it does require that the power supply has adequate input surge protection and grounding.
- F. A separate signal cable is required to provide a signal from the flow meter. The signal cable shall be factory sealed at the meter.

2.6 VARIABLE FREQUENCY DRIVE

- A. The variable frequency drive (VFD) shall be suitable for operation of 480v, 3Ø, 20hp pump motors. The VFD shall have an analog 4-20ma input to control the speed of the pump and digital inputs to control the start, stop, reset, and manual/automatic operation from the MCU. The VFD shall have digital outputs for running and fault conditions to operate pilot lights on an auxiliary panel at the pump control panel/enclosure and to signal the MCU of its operational status. The VFD shall be suitable for outdoor operation and be self-cooled such that operation in an outdoor-ventilated cabinet in summer ambient conditions shall not result in de-rating of the unit.
- B. Operation of the VFDs shall be pulse width modulation with sensorless vector control and shall contain automatic restart and retry options.
- C. The VFD shall be suitable for operation with motors up to two hundred feet from the VFD.
- D. The VFD shall be in its own NEMA 3R enclosure to protect it from dust, dirt, and moisture.
- E. The VFD shall be programmed and operated with an onboard LCD display and keypad.

2.7 MEASUREMENT AND CONTROL UNIT (MCU)

- A. Measurement and Control Unit (MCU), to be located in the pole barn, shall acquire readings from the flow meters, well water level transducers and piezometers. All raw reading values shall be converted to engineering units. Both raw and calculated values will be stored. These values and the reading values of the river stage gage will be used to determine the pumping rate from a stored look-up table. The resulting value of pumping rate is sent via analog output to the VFDs. A secondary function of the MCU is to further adjust pump flow rate to maintain "zero" gradient condition across the barrier wall as measured by the automated piezometer pairs. A third function of the MCU is to send all readings data to the host/remote access PC.

- B. The MCU and related equipment shall be mounted in a single enclosure located inside the pole barn. This enclosure shall be a NEMA 4x enclosure with either a lock or an entry key. The Contractor shall provide a drawing of the final configuration for review by the Designer before installation.
- C. Power to operate the MCU and related equipment shall be 120VAC.
- D. All wiring shall enter and exit the enclosure via rigid conduit. All MCU cabling shall be in metal conduit. All entry points to the enclosure shall be sealed against moisture and shall use water resistant fittings.
- E. The enclosure and all equipment shall be grounded to a suitable earth ground using components as specified by the equipment manufacturer.
- F. Every input/output signal cable shall first pass through a surge protection device at the MCU to protect the MCU from potential electrostatic discharge and potential lightning induced power surges.
- G. The MCU measurement module shall be capable of storing up to one year of data in memory.
- H. The MCU shall have battery backup to insure performance integrity for at least two days without primary power.
- I. The measurement module shall save the program code in non-volatile memory, such as EEPROM, so that after a complete loss of 120VAC power and battery backup, the device shall have the last saved program contained in the system.

2.8 COMMUNICATIONS

- A. All communications from the MCU to the Host/Remote Access shall be via dedicated telephone line.
- B. Appropriate optically isolated surge protection shall be provided for the telephone line. All equipment is to be approved by the Designer before work can commence.

2.9 POWER SUPPLY

- A. MCU shall have a backup battery. Battery operation shall allow the MCU to operate during times that the primary power has been disrupted.
- B. The battery shall provide the MCU at least two days of normal operation without primary power present.

- C. A separate 24 VDC power supply shall be furnished and installed for the flow meters. The contractor shall have the power source approved by the Designer before installation. This power supply does not require battery backup.

2.10 UNATTENDED PHONE DIALER

- A. There shall be an automated phone dialer to send unattended phone, pager, fax, or email messages in case of a system fault. Messages are to be logged and delivered via the phone line whenever there is a pump fault or failure as determined by the VFD programming and output by the VFD controller to the MCU.
- B. The MCU shall be wired to the phone dialer to deliver digital voice, fax, or email messages of the fault condition.
- C. Reporting response time for a failure shall be less than one minute.
- D. The phone dialer shall be programmed for up to 32 destinations and have 8 independent inputs for up to 8 unique messages.

2.11 ACMS HOST/REMOTE ACCESS PC REQUIREMENTS

A. GENERAL REQUIREMENTS

The ACMS Host/Remote Access PC will provide access to the on-site MCU for authorized on-site or remote users. This computer will be used by Owner personnel to obtain automated instrument readings, be advised of any potential alarm conditions and provide the ability to adjust reading frequency and provide remote trouble-shooting of the ACMS.

B. ACMS HOST COMPUTER HARDWARE REQUIREMENTS

1. The ACMS Host Computer shall have the following minimum configurations:
2. Processor – minimum 1Gz Pentium IV or equivalent.
3. Memory - Minimum of 512 Mb of random access memory
4. Hard Disk – minimum 20GB
5. Operating system shall be desktop version of Windows 2000 or Windows XP.
6. I/O: CD-RW for reading and writing data, two serial ports, parallel printer port, USB port, mouse, keyboard, and 56K optically isolated modem.

7. Backup - Travan or equivalent 20GB tape backup unit. Contractor is to supply five tapes.
8. Monitor - High-resolution 17-inch, 0.26-inch dot-pitch or better.
9. Printer - Color Inkjet, HP 9xx series or better
10. Battery Backup - Suitable model shall allow at least 20 minutes of operation, including the monitor, without primary power. The model selected shall also provide lightning protection of all equipment plugged into it and shall include the PC, monitor, and any radio modem, but not the printer. Complete lightning protection, as recommended by the manufacturer, may require that the contractor provide a separate hard connection to the building ground.
11. The PC serial port shall allow the radio modem to operate with the software supplied from the RMU vendor.

C. ACMS HOST COMPUTER SOFTWARE REQUIREMENTS

The ACMS Host Computer shall have the following minimum software applications:

1. Geomatics 2380 Series GeoNet Suite Software (latest version) - The software is used to configure the MCU (Geomatics 2380), monitor the ACMS, and provide necessary data transfer capability.
2. Microsoft Office 2000 Professional.
3. PCAnywhere from Symantec Corporation - this software will provide remote access to the ACMS Host Computer for remote users.
4. Anti-virus software (Norton or equivalent).

D. MCU ENCLOSURE

1. Material - Steel construction, enclosure 16 gauge minimum, door 14-gauge minimum.
2. Finish - Dip-bath primed and powder coated.
3. Ratings - IP 66, NEMA 4.
4. Installed components:
 - a. MCU equipment.

- b. DIN Rail terminals for each MCU at the maximum expanded capacity. Pre-wiring shall be provided between all installed MCU I/O modules and the DIN rail mounted terminals.
- c. Test jacks for each DIN rail terminal for manual readings, test and field calibrations.
- d. 24 VDC Excitation power supplies.
- e. 4-20 ma converters for converting 0-10v outputs from the MCU to 4-20ma to send signals to the VFDs
- f. Barometer for measuring the barometric pressure to compensate non-vented piezometer readings.
- g. Telephone auto-dialer for sending fault condition messages.
- h. Transient protection hardware.
- i. Cable gland feed-through panel.

PART 3 EXECUTION

3.1 INSTALLATION

- A. The Contractor shall be responsible for complete installation of all system components, cable, conduit, instruments, transducers, sensors, variable frequency drives, enclosures, power connections, and miscellaneous items to make the ACMS completely operational.
- B. The measurement and control unit (MCU) shall be located in an enclosure mounted on the south wall inside the pole barn.
- C. The ACMS installation shall comply with all applicable codes and regulations. The work shall be in accordance with the contract documents and shall include: furnishing all labor, tools, equipment, material, installation supervision; receiving, storing, and protecting of equipment and supplies; maintaining up-to-date construction drawings, test and calibration reports, sensor and instrument locations with serial numbers and calibration data, and checking, testing and calibration of all instruments.

3.2 ACMS CONFIGURATION AND PROGRAMMING

- A. General - The contractor **shall be responsible** for all ACMS programming to provide measurement, data conversion, processing, and data logging schedules for each instrument as shown on **the Drawings**. In addition, the contractor shall create the necessary pumping rate control algorithms to send signal set points to the variable frequency drives that control the extraction well pump motors. Secondary control protocols are required to **maintain a "zero" gradient condition** across the barrier well as monitored by the **automated piezometers**.
- B. Qualified Personnel - ACMS programming shall be performed by a representative of the manufacturer or a qualified instrumentation system technician with demonstrated experience with such programming.
- C. Documentation - The Contractor shall provide all documentation related to ACMS programming to the Designer. All changes in configuration and programming shall be submitted to the Designer within 30 days of such changes.
- D. Measurement and Control Unit configuration and programming:
 - 1. The MCU shall be **programmed** to take a set of readings of all transducers on an hourly basis.
 - 2. The MCU shall convert **the automated piezometer readings** to elevations in feet and hundredths of a foot **after the readings are compensated for changes in barometric pressure and temperature**. The barometric pressure reading shall also be stored. Flow meter readings shall be reduced to nearest 0.1 gallons per minute.
 - 3. The MCU shall store **the raw readings** as well as the engineering unit conversions of the **readings in memory**. The raw reading for the vibrating wire transducers shall be **the frequency** in Hz. The raw reading for the flows and barometer shall be **the input voltage**.
 - 4. Every set of readings **shall be date and time stamped** using the 24-hour clock. This applies to **timed readings** as well as forced readings.
 - 5. Every set of readings, **including date, time, raw, and calculated values** shall be stored at the MCU for **download via telephone connection** by the ACMS Host/Remote Access Computer.
 - 6. Instrument readings **shall be stored** in the database of the MCU vendor's interface program in ODBC format.

3.3 TESTING

- A. Final Acceptance Test - **Once** installed the ACMS system shall be tested for operation by qualified personnel. The ACMS Host Computer shall be tested to be sure that data collection and control commands perform reliably. The programming shall be verified by testing instrument data acquisition, data conversions, logging functions, and alarm functions. The Contractor shall prepare an ACMS Acceptance Test Plan for review by the Owner. Once approved, the Acceptance Test Plan will be used to verify the all ACMS functions perform properly. Successful completion of the Acceptance Test, to be conducted with Owner representatives, will indicate final acceptance of the as-installed system by the Owner.
- B. Instrument Interface/Calibration - Verify instrument ACMS interface is operational and that each instrument is properly calibrated, and the correct engineering units have been applied.
- C. All grounding locations shall be tested using the "Fall-of-Potential" test method. All grounding installations shall meet manufacturer's recommendations for appropriate transient protection.

3.4 TRAINING

- A. General - The contractor shall be responsible for providing a 2-day on-site training program for Owner personnel. Training is to be provided covering the subjects of system setup, maintenance, configuration, re-configuration, and system troubleshooting. The equipment training is to be provided in a project-specific context.
- B. Qualified Personnel - ACMS training shall be provided by a representative of the manufacturer or a person authorized by the manufacturer as qualified to provide such training.

3.5 MAINTENANCE

- A. General - For the duration of the contract, the contractor shall be responsible for all costs associated with maintenance of the ACMS. The contractor shall be responsible for all damage to the equipment, and the cost of replacement and repair of any damaged equipment. The complete system, and all spare equipment designated in the Equipment List, shall be turned over to the Owner at the end of the contract, and demonstrated to be in good working order.
- B. Field-replaceable On-site Spares: Spare parts for the ACMS equipment shall be furnished as follows:

<u>Quantity</u>	<u>Description</u>
1	Geomation Rechargeable battery
1	Geomation Battery charger module
2	Geokon 4500S 0-50 PSI transducers with 150 ft of factory installed cable
2	Geomation Transient arrestor (20 wire)
2	Geokon LAB3 Surge Protection Module

C. Troubleshooting, Repair and System Updates - The Contractor shall provide a one-year Technical Support Contract, to commence immediately following contract closeout, with the manufacturer for telephone and product update support as follows:

1. Troubleshooting assistance for system-wide problem identification.
2. Corrective maintenance in the event of an ACMS system malfunction, using the available field-replaceable on-site spares.
3. To provide factory repairs for failed ACMS equipment components, on a return-to-factory basis, for subsequent return to on-site spares inventory.
4. To provide all updates of ACMS software released during the period of the contract. Such updates shall be provided to the Designer, who will make the decision as to whether or not the update will be installed. If the Designer decides that the updates are in the best interest of the project requirements, the updates shall be performed under the direction of the Designer, who may also provide any new instructions to the contractor for day-to-day system operation associated with this update.
5. At the end of the one-year technical support contract the Contractor shall provide a one-day, on-site refresher course with Owner personnel. The purpose of the course shall be to review and verify that all aspects of the system are operational and that data is being recorded and stored properly and that the Owner understands how to best use the system, troubleshoot the system, maintain the system, and obtain future technical support.

TABLE 6-1

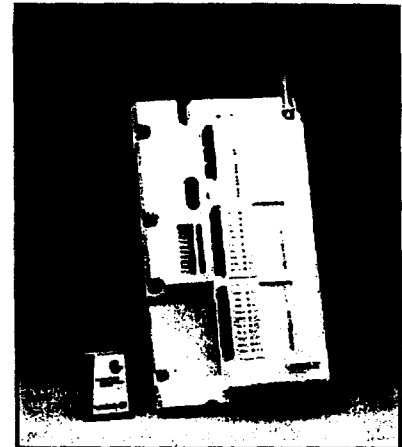
Pumping Rate Lookup Table		
River Stage (ft, amsl)	Pumping Rate (gpm)	River Elevation Comments
430	0	Highest Recorded River Elevation
413	0	
412	25	
411	50	
410	75	
409	100	
408	125	
407	150	
406	175	
405	200	
404	225	
403	250	
402	275	
401	300	High Monthly Average Flow
400	325	
399	350	
398	375	
397	400	
396	425	
395	450	
394	475	
393	500	
392	525	
391	535	Average Monthly Average Flow
390	550	
389	575	
388	600	
387	625	
386	650	
385	675	
384	700	
383	725	Low Monthly Average Flow
382	750	
381	775	
380	800	
379	825	
378	850	
377	875	
376	900	
375	925	
374	950	Lowest Recorded River Elevation

END OF SECTION

2380 SERIES MCUs



→ 2380/80 MCU



2380/20 MCU

APPLICATIONS

Geotechnical & Structural

- Monitoring Large Civil Construction
- Dam Performance Monitoring
- Dam Early Warning Systems
- Slope Stability Monitoring
- Tunnel & Mine Monitoring
- Bridge & Building Monitoring
- Pipeline Strain Monitoring

Industrial Facilities

- Water Collection & Treatment
- Water Storage & Distribution
- Canal Monitoring & Regulation
- Irrigation System Control
- Gas Well Automation
- Equipment Performance Monitoring
- Energy Distribution & Accounting

Environmental

- Water Quality Monitoring
- Stormwater & Discharge Monitoring
- Conditional Sampling Control
- Flood Warning Systems
- Air Quality Monitoring
- Electronic Weather Stations
- Groundwater Remediation

FEATURES

Configuration Flexibility

- MCUs Operate Stand-Alone or in Multi-Node Networks
- Plug-In I/O Modules Provide Application Flexibility
- Model 20 Accepts One or Two I/O Modules
- Model 80 Provides Expansion to 8 I/O Modules
- Model 80 Suitable for Industry Standard 19" Rack Mounting
- Engineered Weatherproof Enclosures and Accessories Make Field Installation Easy and Reliable

Operation & Functions

- GEONET™ Suite Provides MCU Programming, Data Logging and Data Reporting
- PCMCIA Card Data Storage for Buffering or Data Retrieval
- PCMCIA Adapter Supports Telephone & Satellite Terminal Modems
- Built-in Communications Features Make 2380 MCUs Network-ready
- Internal or External Battery Operation with Built-in Charging
- Battery Recharging by AC, Solar or Both; Ultra Low Power Modes Allow Replaceable Battery Operation

Test & Maintenance

- Plug and Header Field Wiring Terminals for Easy Testing
- MCUs and I/O Expanders are Modular for Quick Field Replacement
- Front Access to All Controls, Indicators and Wiring Terminals
- Simple Diagnostic Indicators Eliminate Guesswork in the Field
- Remote Diagnostics are Provided through GEONET Suite
- Integral Protective Grounding System and Effective Transient Protection

INTRODUCTION

The 2380 Series Measurement & Control Units (MCUs), together with GEONET Suite PC software, provide a comprehensive system for field data acquisition and control. Whether your application is for a stand-alone field data logger, or a mission-critical real-time network with hundreds of field nodes, Geomation 2380s are the building blocks that make it easy, predictable and cost effective. Also, 2380s are backward-compatible with existing System 2300 networks, requiring only an upgrade to GEONET Suite and Windows 95, 98 or NT.

The 2380 is a third generation standard product MCU from Geomation, building on the features and capabilities of our innovative System 2300 introduced in 1986. The 2380, employing advanced electronics and software technology, brings substantial improvements to the internationally proven Geomation System 2300 architecture. The 2380 MCU, with the new System 2300 data server, GEONET Suite, introduces new capabilities for linking field-distributed instrumentation with enterprise information management systems using open-architecture 32-bit database technology. (See separate Product Data on GEONET Suite.)

System Costs and Economies

Historically, the economic advantages of the Geomation System 2300 have been most apparent to customers who have experience with field automation in one of the following ways:

- 1) Users with prior experience in field instrumentation systems often recognize the substantial expense of system integration that is avoided by the "total system solution" provided by the Geomation System 2300.
- 2) Many SCADA System users have endured the frustrations of working with systems implemented with custom software components. Almost without exception, custom implementations fail to meet objectives without substantial and costly on-going support. Custom software support at any price eventually becomes nonviable on

hardware and software platforms that reach obsolescence.

Many of these users have been quick to recognize the value of standard products which can be user programmed to meet their initial and changing needs.

To a large extent, the cost advantages of the System 2300 have been most apparent to people having relevant experience and therefore a practical basis for understanding the impact of system architecture on "cost of ownership". When product capabilities are not well conceived from a total system standpoint, or they are incomplete requiring custom low-level software development, then the costs of system use and technical support far exceed the initial cost of the equipment.

The economic benefits of the System 2300 today are based on the same issues that have contributed to its success over the last decade. Specifically, the total system solution provided by the System 2300 mitigates significant cost in the areas of installation, system start up and ongoing support. In short, an umbrella of capability minimizing technical risk comes to the customer straight out of the box from Geomation.

With the introduction of the 2380 MCU, the System 2300 is now even more economical in the initial purchase price, installation, and ongoing support for a wider scale of applications than ever before.

Stand-Alone Data Loggers

The new PCMCIA Adapter allows the 2380 to operate as a stand-alone field data logger, without a PC connection. Data logged to an optional on-board PCMCIA memory card in the 2380 can be read by your laptop or desktop PC equipped with a standard PCMCIA adapter. Programming modifications can also be transferred to field-deployed MCUs with PCMCIA memory cards, eliminating the need to take expensive laptop computers to the field.

Even further, as a logging destination node in a multi-node network, the 2380 MCU introduces an entirely new class of datalogger: a field distributed data logger.

The distributed data logger is a practical configuration for widely separated instruments. A wireless network can provide easy data transport to a single, accessible logging location where the data can be easily retrieved.

Progressive installations are often desirable in construction monitoring situations. 2380s allow economical data logging during construction, and they are easily connected into multi-node networks for long term performance monitoring when the new structure is completed. The System 2300 can begin as one data logger, then two, and so on, and finally be connected as a real-time monitoring system. The 2380 MCU allows this to be done without cost penalty, either up front or at the end.

Field Networking Anywhere

A hallmark of Geomation technology over the history of the System 2300 has been the innovative and robust user configurable networking capability. Geomation MCUs are network-ready by design. MCUs can be linked by radio, wireline, microwave and public communication networks (including satellite).

2380 MCUs support a minimum of three concurrent inter-node connections, all of which can be different physical connection types. Communication capabilities support bridging and repeating to allow transitions from a wireline sub-network branch to a radio sub-network branch. As another example, one node in a field deployed radio network can be located near a telephone line or a satellite terminal, providing remote project linkage for all MCUs to a distant GEONET Workstation through a public communications access point. These examples of inter-networking satisfy the often required bridging from Remote Area Networks to Wide Area Networks.

INTRODUCTION *(continued)*

Private microwave or satellite networks can be used in the same way to extend wide area coverage. These capabilities allow practical, low cost field deployments in virtually any project situation, making optimum use of existing communication infrastructures. All connections, including telephone-switched connections, are user configurable through GEONET.

Enterprise Connections

With the new SQL database provided in GEONET Suite, the System 2300 supports open-architecture client/server operation for on-line data management, analysis and decision support throughout customer organizations. Other client software programs supporting the ODBC (Open Data Base Connectivity) industry standard, running on Windows 95, 98 or Windows NT can inter-operate seamlessly with GEONET as a real-time data server. As an example, graphic Operator Interface (OI or MMI) and data analysis programs can inter-operate across the enterprise with real-time field data served by the System 2300.

System Scalability

Scalability is a concept for modeling the economy and practicality of different system architectures for applications of varying dimensions. These dimensions typically involve the number of connected devices, and the spatial as well as environmental distribution of the devices. Designing automation systems for high scalability in remote and harsh environments requires special consideration for resources that are taken for granted in systems used strictly in plant or factory environments.

Scalability for arbitrary field automation situations must address the communication requirements for both wide-area, and local/remote-area deployments. On a smaller scale, at the MCU, practical range is imposed for critical resources. When the Remote Unit is located in harsh environments, marginal resources can have a dramatic effect on system reliability and performance.

Major issues include: a) range and cost of I/O expansion, b) ease and practicality of networking multiple nodes in the target environment, c) adequacy of communication bandwidth and system throughput time vs. I/O loading, d) adequacy of power resources at remote nodes for the required instrumentation, data measurement and communication rates, and e) environmental integrity of the electronics packaging in outdoor installations.

The System 2300 is a general purpose system designed for adaptation to a variety of field automation applications and specific project requirements. The success of the System 2300 comes from high scalability in system architecture while supporting extensive user programmability for measurement, control and communication functions. Successful system configuration is easy in spite of inevitable variations in application and field conditions. Perhaps most important, flexibility has been implemented in a way that does not compromise the overwhelming benefits of standard products: reliability, predictable performance, cost, and long-term support.

The 2380 MCU improves System 2300 scalability on every design issue. The most apparent for existing customers is I/O scale. Our historical product line had evolved into two different MCUs to handle variations in I/O scale: The 2350 for large I/O expansion and the 2370 for small I/O count.

The new 2380 MCU is more economical, simpler, and easier to use over a broader range of I/O requirements. Therefore, the 2350 and 2370 MCUs are now both succeeded by the 2380 MCU.

Universal I/O Support

The 2380 MCU is designed to interface to virtually all industry standard analog type transducers and sensors. In addition, MCUs have built-in resources to measure some of the more specialized devices used in hydrological, environmental, and geotechnical applications. Examples include rotary position encoders for water level measurements, digital interfaces for multi-

parameter water quality instruments, and vibrating wire sensors used in civil construction applications.

The 2380 has built-in resources for wide dynamic range voltage, resistance, current and frequency measurements, with various excitation sources and operational modes. Field-pluggable I/O Modules support the physical connection, signal routing and multiplexing requirements of a wide range of transducers, sensors and device actuators. Application flexibility is accomplished by selecting the appropriate I/O Module(s) and invoking the measurement (and control) functions built into MCU firmware using GEONET. The enabling of instrumentation functions is downloaded to the MCU locally through a serial port, remotely over a network, or via a PCMCIA card.

Environmental Integrity

Exclusive use of industrial and military grade CMOS electronics assures compatibility with temperature extremes for outdoor installations.

The 2380 MCU has been designed with a very high level of systems integration. The result is a reduction in component count and inter-connections, with increased reliability. High integration also permits more reliable and compact enclosure designs for outdoor environments, with improved defenses against vandalism.

Simple System Operation

The Geomation System 2300 has long been recognized for its ease of operation and user configurability. The high-level user programming methodology facilitated by GEONET leads to the creation of reusable "software instruments".

The 2380 MCU and GEONET Suite extend the usefulness of the software instrument concept by introducing user defined instrument Groups and DataSets. Groups and DataSets allow arbitrary groupings and preprocessing of data for exporting to Excel, Word, and other analysis programs.

MCU ARCHITECTURE

Installation & Maintenance

The 2380 MCU has been designed with simple diagnostic indicators visible from the front panel for all essential functions: power, charging, communication ports, and all I/O points. Simple LED indicators provide unambiguous information regarding proper operation, without language barriers. Installation and maintenance is easier for people without specialized skills.

High Integration & Modularity

The 2380 MCU architecture employs advanced electronic technology to implement very high integration of all essential functions. In addition, the base instrument includes the foundation resources to support strategic optional capabilities. Plug-in options are provided for the functions and interfaces which vary according to application requirements. The benefits of 2380 architecture are the reliability and economy which result from high integration of all base functions, and the adaptability offered by plug-in modularity for the variable instrumentation, data storage, and communications requirements.

The 2380 Architecture includes an extensive library of built-in software functions, which allows MCUs to be easily field-configured to fit specific user applications. Most importantly, application-specific configurations are allowed with a minimum of system components and complexity exposed to the user.

In addition to MCU options, Geomation provides a complete complement of engineered accessories for reliable installation and maintenance. The extent of 2380 Series MCU capabilities and the completeness of the Options and Accessories which work in concert with 2380 MCU architecture minimize the costs and difficulties of installation and maintenance. A further result is that standard product reliability and product warranties are offered at a higher "total system solution" level with the System 2300. The 2380 Series MCU Block Diagram

identifies the base functionality included in the 2380 MCU architecture, and shows the general relationships of these functions to one another. Geomation provided optional plug-in functions are also shown in the diagram. The Specifications section of this document describes interfacing capabilities to certain external devices and protocols.

Distributed Multi-Processing

The 2380 MCU main system microprocessor interfaces with all MCU hardware via a real-time, multi-tasking executive kernel. The multi-tasking environment allows the MCU to process multiple tasks efficiently, without error, and in proper sequence in spite of the unpredictability of task execution which results from arbitrary user programming.

I/O Modules have separate microcontrollers, with support for multi-processing and bus mastering with the main CPU bus. This means, for example, that the main CPU can go into a deep-sleep mode, conserving power, while certain types of I/O Modules remain fully operational with very low power consumption. The I/O Modules can wake up the main CPU in case of an event requiring CPU resources (e.g., communicating an alarm event to the specified logging destination).

In the general architectural model for processing and memory resources, the main CPU can handle all tasks for a fully-loaded MCU with any allowable complement of installed options.

Time-Keeping & Synchronization

The fundamental difference between MCUs and the Remote Terminal Units (RTUs) of conventional SCADA system architecture is that MCUs are functionally autonomous for local data acquisition, control and communication, while RTUs execute tasks under the timing and direction of a host computer. In other words, MCUs employ a distributed intelligence architecture in normal system operation.

Even though MCUs operate autonomously, they are not isolated. MCUs can share

information with each other (peer-to-peer communication) to implement distributed control or wide-area regulation strategies, with central intelligence if required. For remote environments, particularly those with limited power and communication bandwidth, distributed-intelligence is the most economical and effective architecture.

Autonomous operation requires MCUs to know about absolute as well as relative time. Furthermore, MCUs can be deployed over multiple time zones in wide area networks, reporting data to computers in more than one time zone. To assure proper synchronization and reporting of the local time of measurements and events, 2380 MCUs maintain a UTC (Universal Time Coordinate) consisting of Greenwich Mean Time (GMT) plus the geo-coordinate deviation from GMT. MCU clocks are synchronized to GMT by GEONET. MCUs maintain GMT so that they do not get reset improperly by connection with a "foreign" GEONET Workstation. The MCU informs GEONET of its UTC for correctly reporting the date and time of data events.

MCU SPECIFICATIONS

Processor: Intel 80L186EC

Program Memory: Flash EPROM, 256Kx16, field loadable, jumper protected boot block, low-level diagnostic and download monitor

Data & Configuration Memory: 256Kx16, non-volatile static CMOS

Mass Storage: PCMCIA solid state disk option

Clock/Calendar: Non-volatile Accuracy: ± 3 sec/month (20°C)

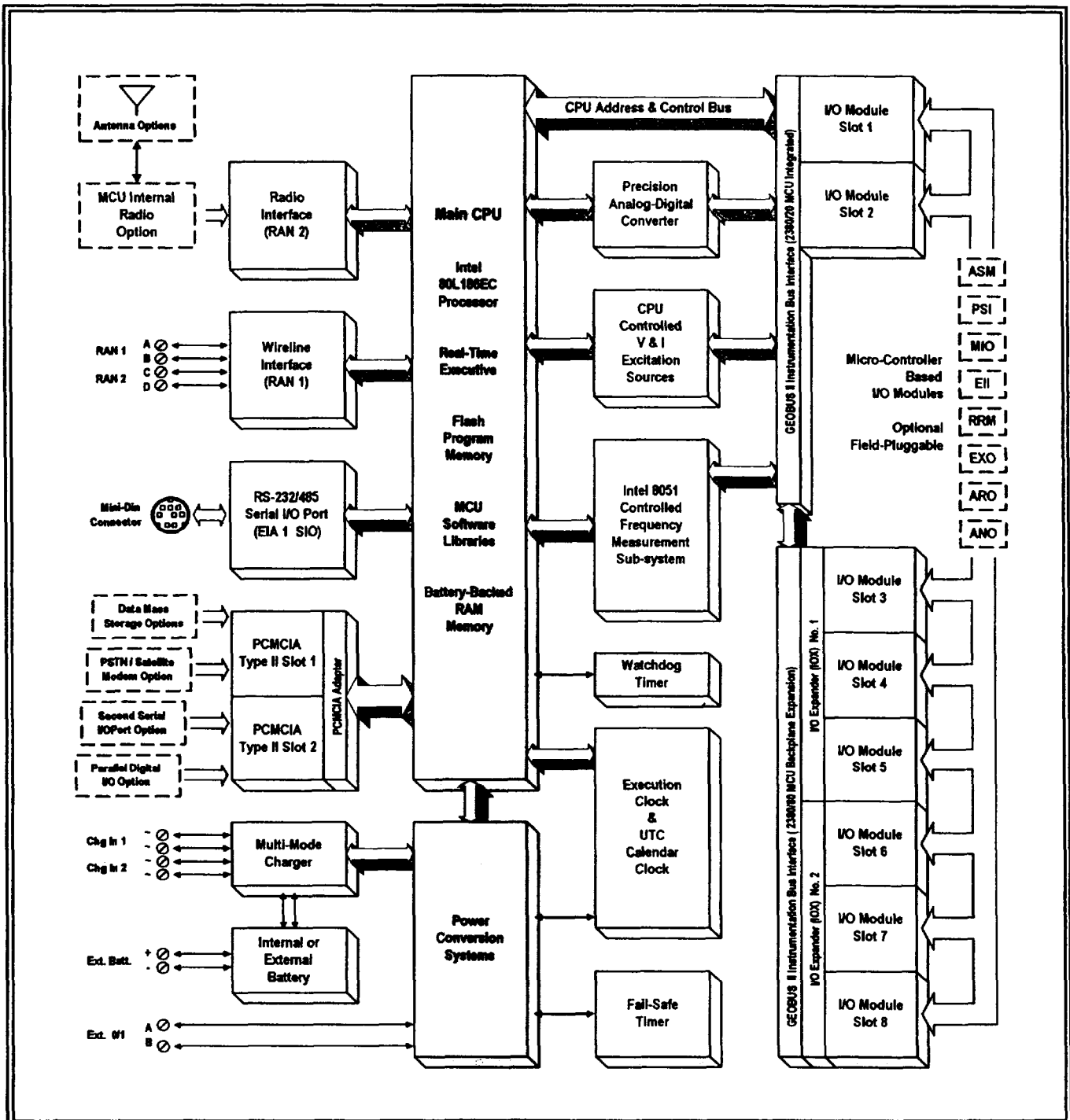
Temperature Coefficient: 50 ppm/°C UTC reporting to GEONET Stations

Watchdog Time-out Interval: 1.2 sec

Fail-safe Timer Interval: 24 hr

Audible Diagnostic Indicator

MCU ARCHITECTURE (continued)



2380 Series MCU Block Diagram – 2380/20 & 2380/80

MCU SPECIFICATIONS (continued)

Communication Ports

• **EIA 1 SIO: Serial Interface (Standard)**
RS-232/RS-485: Software auto-switched
Functions: GEONET Communications Protocol (GCP), Geomation 2390 Series Field Instrument Transponders (FITs), external RS-232/RS-485 connections to 3rd party intelligent instruments
Transient Protection: 600W suppressor diodes, ± 15 V common-mode voltage
Connector: 8-pin miniature circular DIN
Indicators: Front panel LEDs: CD, Rcv, Xmt

• **RAN 1: Wireline Interface (Standard)**
Configurations: 2-wire/4-wire, field strapable
Interface: transformer isolated, 600 Ω
Signaling: CCITT V.23, 1200 bps, FSK
Transmit Levels: +3 dBm, 0 dBm, -3 dBm, -6 dBm, -12 dBm, -16 dBm, field setable
Receiver Threshold: -43 dBm, 2.5 dBm hysteresis
Adjustments: CD level, FSK symmetry
Indicators: Front panel LEDs: CD, Rcv, Xmt

• **RAN 2: Radio Interface (Standard)**
Function: Supports internal Geomation radio transceiver option
Signaling: CCITT V.23, 1200 bps, FSK
Adjustments: CD level, FSK symmetry
Indicators: Front panel LEDs: CD, Rcv, Xmt (See Radio Option for transceiver specifications)

• **EIA 2: Telephone Modem (Optional)**
Interface: PCMCIA Adapter
 (See Telephone Network Modem option for specifications.)

• **SDI-12: USGS Fieldbus (Optional)**
Interface: Implemented through the EII (Environmental Instrument Interface) I/O Module

Communication Protocols

• **INTER-UNIT PROTOCOL:**
GEONET™ Communications Protocol (GCP)
Type: Proprietary peer-to-peer packet protocol based on SDLC

Error Detection Algorithm: CCITT CRC-16

Link Security: Node-to-node verification and acknowledgment

Network Security: Source node message buffering until end-to-end verification and acknowledgment

Network Services: Field programmable and adaptive message routing. Store-and-forward message routing, repeating and bridging. Message forking to multiple logging destinations.

Application Services: Link failure detection and alarming, with link re-routing capability

Physical Link Support: Point-to-multipoint wireline, radio, microwave, fiber-optic. Point-to-point RS-232, auto-dial/auto-answer PSTN (including cellular).

• FIELD INSTRUMENT PROTOCOLS

Partial list of intelligent instrument drivers implemented in the 2380 MCU, with configuration interfaces implemented in GEONET™ Suite:

Geomation: 2390 Series Field Instrument Transponders (FITs)

USGS: SDI-12 low-power fieldbus

PCMCIA Interface

Physical: Standard PCMCIA interface supports 5 V or 5V/3V PCMCIA cards

Slots: Two Type II

Software Support: Geomation supplied optional mass storage memory cards, telephone modem card, serial I/O card, and parallel digital I/O card.

On-Board Diagnostic Measurements

The system measures and stores by default the following parameters related to the health and well-being of the MCU and its critical subsystems and resources.

Unit Temperature

System Battery Voltage

Charging Voltage

Backup Battery Voltage

Fully Charged Battery: Front panel LED indicator

Charger Mode State: Front panel LED indicator

Communication Port Statistics

Reboot Counters

Calibration Constants: Reference voltages, resistance standards, frequency

Frequency Measurement Subsystem

• EXCITATION

Mode and timing parameters user selectable on an individual measurement channel basis

Single Chirp: Swept square wave from 300Hz up to 1, 2, 3, 4, or 5kHz

Double Chirp: Swept square wave followed by a gated square wave at the frequency of best response

Specified Sweep: Swept square wave from specified starting and ending periods

Duration: 0, 50, 100, 200, 300, 400, or 500 msec

Amplitude: 10Vp-p, zero DC component

• RECEIVER

Bandpass Amplifier: 400Hz to 5000Hz

Sensitivity:

450Hz to 5500 Hz <0.1mV RMS

250Hz to 12000 Hz <10mV RMS

Input Impedance: 5KW at 1KHz, transformer coupled

• PERIOD MEASUREMENT

Method: Time interval for 256 cycles of received signal

Triggering: Triggers and counts on zero crossings

Resolution: 4nsec

Accuracy: $\pm 0.002\%$, 1 year, $T_{cal} \pm 5^\circ\text{C}$

Temperature Drift: $\pm 0.01\%$ -20°C to 55°C
 $\pm 0.05\%$ -40°C to 70°C

DC Measurement Subsystem

• FRONT END

4 Ranges: Differential $\pm 0.1\text{V}$, $\pm 1\text{V}$, $\pm 10\text{V}$, $\pm 50\text{V}$ full scale with 30% overrange, user programmable discrete or autorange per-channel

• ANALOG-TO-DIGITAL CONVERSION

Type: Delta-sigma

Resolution: 19 bits + sign

ADC Throughput: Up to 20 readings/sec

Measurement System Speed: Up to 5 autoranges/sec

PRODUCT DATA

2380 Series MCUs

MCU SPECIFICATIONS (continued)

• SELF CALIBRATION

Method: Interlaced cycles of internal reference sources applied to the front-end
Reference Sources: 10V, 1V, 0.1V, 0V
Long Term Drift: [reference]
Temperature Coefficient: 0.7ppm/°C

• DC VOLTAGE

Range: ±100mV ±1V ±10V ±50V
Full Scale: ±130mV ±1.3V ±13V ±50V
Resolution: 140nV 14μV 140μV 1.4mV
Accuracy: .005+.01 .005+.01 .005+.008 .01+.02
 (% reading + % range)
CMRR: >95dB >85dB >80dB >75dB
 (DC, 50Hz, 60Hz; 1kW source imbalance)
ZIN: >100MΩ >100MΩ >100MΩ 1MΩ
Max Input:
 (H, L to G): ±50V ±50V ±50V ±50V

• DC CURRENT

(Using ASM 50W shunt resistors)

Range: ±2mA ±20mA ±200mA
Full Scale: ±2.6mA ±26mA ±260mA
Resolution: 3nA 30nA 0.3mA
Accuracy: .005+.01 .005+.01 .005+.01
 (% reading + % range)
Max Current: ±70mA ±70mA ±70mA

• CURRENT TRANSMITTERS (Using Base Unit 20W shunt resistor)

Loop Excitation: 24VDC
Range: ±4mA ±40mA
Full Scale: ±5.2mA ±52mA
Resolution: 6nA 60nA
Max Current: ±120mA ±120mA

• RESISTANCE

Scale: 100Ω 1kΩ 10kΩ 100kΩ
Excitation: 5V/70Ω 10V/10kΩ 10V/10kΩ 10V/10kΩ
Range: 120Ω 1.4kΩ 10MΩ 10MΩ
Accuracy:
 100Ω ±0.01Ω ±0.1Ω ±1Ω ±1Ω
 1kΩ — ±0.1Ω ±1Ω ±1Ω
 10kΩ — — ±5Ω ±5Ω
 100kΩ — — ±50Ω ±50Ω
 1MΩ — — ±500Ω ±300Ω

• DC EXCITATION SOURCE

Routing: Can be switched onto any ASM channel under user program control

Voltage Source —

Level: +5V, +10V, +15V, +24V user selectable
Accuracy: ±5%
Noise & Ripple: (20MHz) 20mVRMS 200mVp-p
Source Impedance: 25Ω typ, 50Ω max
Max Current: 100mA

Current Source —

Level: 100mA
Accuracy: ±2%
Compliance Limit: 13.5V
Noise & Ripple: (20 MHz) 7μAp-p

Power Supply Limits

• POWER CONTROL

Switches: External power switch, internal power switch, main battery disconnect, backup battery disconnect
Operating Modes: Active, idle, sleep, backup
Sleep Activation Sources: Executive commands, Sleep component evaluation, power-miser state detection, low main battery detection, power switch off-transition, software fatal error detection
Boot-up Activation Sources: Main power restored, power switch on-transition, alarm clock wake-up, watch-dog wake-up, fail-safe timer wake-up, GEOBUS Module event detection
Audible Mode Indications: Boot-up, unit active, entering sleep state, resident monitor active

• POWER CONSUMPTION

(Based on 12V main supply battery)
Fully Active: 30mA (excludes sensor excitation, optional equipment)
Idle: 20mA (unit awake, but waiting for something to do)
Sleep: 300μA (system shut down, memory retained clock/calendar operating, re-start circuits operational, fail-safe timer running)
Backup Mode: 3μA typ, 50μA max (lithium cell operation, memory retained, clock/calendar operational. Invoked when main battery detached or below 9V)
Absolute Max. Supply Voltage: 16VDC
Absolute Min. Supply Voltage: 10.5VDC

• CHARGER

Type: Multi-stage charge regulator for lead-acid batteries. Automatic low-battery load shedding
Inputs: Dual inputs, AC/DC with DC/DC conversion and thermal shutdown
Min. Charge Input: 17VDC or 17VRMS AC
Max. Charge Input: 35VDC or 35VRMS AC
Low Battery Trickle Current: 25mA
Charge Enable Threshold: 9VDC
Maximum Charge Current: 0.8A
Overcharge Voltage Limit: 14.5VDC
Float Regulation Voltage: 13.8VDC
Charge Shutdown Threshold: 8VDC
Thermal Shutdown: 70°C
Load Shed Threshold: 9.0VDC (can be manually actuated by on-board switch)
Load Restore Threshold: 12VDC
Indicators: Two (charging, fully charged)

Environmental Specifications

• MCU & I/O MODULES

Operating Temperature: -40°C to +70°C
Storage Temperature: -60°C to +125°C
Relative Humidity: 8% to 95%, non-condensing
Operating Altitude: to 4600m pressure altitude
Storage Altitude: to 15,200m pressure altitude
Transient Protection (all connections):
Surge Withstand: IEEE 472 (ANSI C37.90a)
Electrostatic Discharge: 15kV

• TEMPERATURE RATING FOR OPTIONS

External Battery (HRB, EXB): -30°C to +70°C
Internal Battery (INB): -10°C to +40°C
Telephone Modem (TNM, CTIK): -0°C to +70°C
Second Serial Port (SIO-2): -0°C to +40°C
FlashDisk Mass Storage (FMS): -40°C to +85°C

GEOBUS II AND I/O MODELS

GEOBUS II Architecture

The GEOBUS II is a design feature allowing the connection of a wide range of instrumentation to MCUs through a family of bus-pluggable I/O Modules. The basic 2380 MCU, the primary assembly in 2380/20 "bundled" configurations, supports 2 I/O Module positions. The 2380/80 MCU configuration offers 8 I/O Module positions thereby expanding scalability for higher density I/O. In the 2380/80, the GEOBUS II is extended through a passive backplane built into a rugged mounting panel, referred to as the 3-Position Mounting Panel (3MP). The 3MP contains one 2380 MCU and two 2380 IOXs (I/O Expanders), providing the 8 I/O Modules positions (See 2380 Series MCU Block Diagrams – 2380/20 & 2380/80).

GEOBUS II Interface

Implementation:

2380/20: Integrated on the MCU System Board, providing for 2 Module positions

2380/80: The MCU integrated bus is extended through a shielded connector on the MCU System Board to a shielded passive backplane on the 3-Position Mounting Panel (3MP). The backplane engages connectors on two 2380 IOXs, providing for 6 additional Module positions, for the total of 8.

Physical: 28kbps serial master-slave, parallel service request lines, analog excitation lines, guarded analog measurement lines, address lines, control lines. Logic level signals with buffer drivers.

Protocol: GEOBUS II Module protocol

Error Checking: Modified CCITT CRC-16

Addressing: Up to 8 I/O Modules in addition to the CPU master and frequency measurement subsystem. Address is determined by physical location on the GEOBUS II.

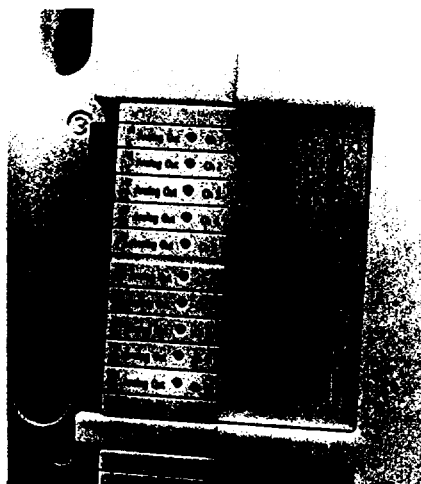
Module ID: Command response reports module type, protocol level, hardware revision, and I/O Module firmware revision. I/O Modules are user installable in MCUs and provide direct-connect interfacing to external sensors, transducers, and device actuators. Modules provide field wiring

General I/O Module Functions

screw terminals, indicator lights, signal routing, signal conditioning, voltage-mode or current-mode excitation, multiplexing, and in some cases, analog and digital signal processing. The organization and behavior of these functions are specific to different types of instruments and control devices. Therefore, a family of function-specific as well as mixed-function I/O Modules are offered to handle these variations economically while providing a uniform digital interface to the MCU through the GEOBUS II. Any I/O Module type can be plugged into any GEOBUS II Module position with identical performance, and there are no exclusion rules among Module types that can be plugged into the bus.

I/O Modules assume their "Card Address" by the position (1 through 8) into which they are plugged on the GEOBUS. Position address identification is molded into the Mounting Panels into which the 2380 MCUs and the 2380 IOXs are normally installed.

ANO Analog — Output



General Description —

The ANO is a general purpose, analog voltage output module for independently controlling up to 10 single-ended voltage outputs. The output voltage range is either 0 to +5V or 0 to +10V and is software

selectable. The module stores calibration information for each range and each channel. In operation, the module scales the requested output voltage by the stored calibration data and sets the output Digital-to-Analog Converter (DAC) to the 12-bit value corresponding closest to the requested output voltage. An indicator lamp for each channel periodically blinks at a rate proportional to the output voltage.

Typical Applications —

- Driving remote analog or digital panel meter displays
- Simple analog interfacing to RTUs and other monitoring systems
- Proportional or error control signals for control-loop monitoring and tuning

Specifications —

Channels: 10

Output Type: Low power, non-isolated voltage output

Ranges: 0 to +5V, 0 to +10V, relative to channel common

Digital-to-Analog Conversion Resolution: 12-bits

Analog Accuracy: $\pm 2\text{mV}$ (10V range), $\pm 1\text{mV}$ (5V range)

Drive Current: 10 mA max

Transient Protection —

Type: Unipolar suppressor diodes

Breakdown voltage: 15V min

Power: 600W peak pulse power

Calibration —

Technique: Calibration data stored on-module in non-volatile memory; field adjustable

Calibration points: Two point calibration for each range and each channel

Labeling: Ch 1, Ch 2, ... Ch 10; two terminals per channel labeled H, C

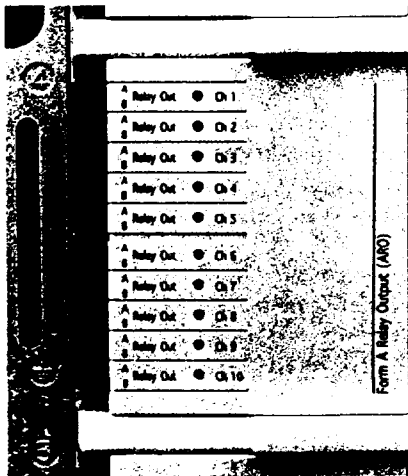
Indicators: One LED for each channel; LED blinks at one of 8 distinct rates proportional to the full scale output

Connectors: 3.5mm pitch screw-clamp terminals (20 terminals per Module)

Wire Size: 28 to 14 AWG

I/O MODELS (continued)

ARO — Form A Relay Output



General Description —

The ARO is a general purpose, relay switching module for independently controlling up to 10 two-wire circuits. Output channels on the ARO can be used to switch DC or AC circuits carrying up to 2A DC or peak AC current, with voltage limits of 68V peak or 48V RMS. The solid state relays are protected from electrostatic transients and inductive load switching surges by 1500W transient voltage suppressors.

ARO relays default to the open circuit condition when the MCU is powered down or in the sleep state, or whenever a hardware re-boot occurs. User programmable MCU Evaluators are available for setting selected switches to the on- or off-state and for triggering on-pulses of programmable duration. An indicator lamp for each switch activates whenever the switch contacts are closed.

Typical Applications —

- MCU programmed control of low-voltage AC or DC circuits
- Solenoid valve actuation
- Hydraulic drive control
- Interposing relay or contactor signaling for controlling motors and pumps
- Small signal multiplexing

Specifications —

Channels: 10

Switching Action: Form A contact closure (normally open SPST)

Switching Elements: Opto-coupled MOSFET relays, AC connected

Input Voltage Limits: (A to B) $\pm 68V_{peak}$, 48Vrms

Current Capacity: 2A DC or peak AC at Input Voltage Limits

Contact resistance: 0.34Ω max

Switch Capacitance: 1400pF typical

Leakage Current: 10 μ A max

Transient Protection: Transient voltage suppressors, 1500W peak power

Type: Bi-directional suppressor diode in parallel with each pair of switch terminals

Breakdown voltage: 68V min

Power: 1500W peak, 14A peak pulse current

Operating Modes: On, Off, or Pulse on. Latest command takes precedence.

Pulse Duration: 0.1 to 6553.5 seconds in 0.1sec increments

Pulse Accuracy: ± 5 msec

Fail-Safe: Contacts open on any reboot, power failure, or when MCU is in sleep mode

Labeling: Ch 1, Ch 2, ... Ch 10; two terminals per channel labeled A, B

Indicators: One LED for each channel; LED lights when channel switch is closed

Connectors: 3.5mm pitch screw-clamp terminals (20 terminals per Module)

Wire Size: 28 to 14 AWG

ASM — Analog Signal Multiplexer



General Description —

The ASM is a general purpose, low-noise Analog Signal Multiplexer for switching up to 10 two-wire circuits into common measurement and excitation resources built into the MCU. The ASM can be used to measure DC voltage, resistance, current, and frequency over multiple ranges. The ASM can also output DC voltage-mode, DC current-mode, and swept AC (chirped) excitation signals under user program control, or under the automatic control of various imbedded "software instruments." Each 2-wire channel has separate measurement and excitation switching which can be applied independently or simultaneously, providing maximum analog excitation and measurement flexibility. Since the ASM enables the MCU for complete multi-channel "multimeter" measurement functions, the ASM is the system workhorse for most general-purpose multi-channel data acquisition applications.

Typical Applications —

- **Voltage Output Transducers:** Low-level and high-level (amplified) devices
- **4-20mA Current Transmitters:** See DC Measurement Subsystem / Current Transmitters
- **Vibrating Wire Instruments:** Direct connection for multiple vendors; see Frequency Measurement Subsystem
- **Thermocouples:** Direct connection for types J, K, T, E, R, S
- **4- and 6-wire DC Resistance Bridges:** "Software Instrument" support for high level programming
- **Potentiometers:** 3-, 4-, and 5-wire configurations
- **DC/DC LVDTs:** With programmed excitation and remote-sense configurations
- **Thermistors:** Direct connection with built-in linearization equations
- **RTDs:** Direct connection with leadwire compensation for 3- and 4-wire configurations

Fundamental Measurements & Excitation —

- **DC Voltage:** See DC Measurement Subsystem / DC voltage
- **2- and 4-terminal Resistance:** See DC Measurement Subsystem / Resistance

I/O MODELS (continued)

- **DC Current Measurements:** See DC Measurement Subsystem / DC current
- **Frequency:** See Frequency Measurement Subsystem
- **Excitation:** DC voltage-mode, DC current-mode, frequency, swept frequency

Specifications —

Channels: 10 analog, 2-wire, programmable as inputs and excitation outputs

Input Configuration: Bipolar, differential
Switching Elements: Opto-coupled, low-thermal offset MOSFET relays. Separately switched measurement and excitation

Maximum Input: (H, L to G) $\pm 50V$

Transient Suppression: 50V bi-directional suppressor diodes per terminal, 1500W peak power

DC Offset: $\pm 2\mu V$ maximum differential

Excitation Sources Available through ASM: 5V, 10V, 15V, 24V, & 100 μA with 15V compliance limit

Excitation Source Impedance: 50 Ω typical

Excitation Duty Cycle: 10sec maximum through ASM, software limited

Thermocouple Reference Junction: On-board electronic reference simulator; can be bypassed for external reference

Thermocouple Reference Junction Accuracy: $\pm 0.5^{\circ}C$, $-20^{\circ}C$ to $+60^{\circ}C$, assuming thermal equilibrium of connection terminals

Thermocouple Linearization Conformity Error

Type J: $\pm 0.5^{\circ}C$, $-225^{\circ}C$ to $750^{\circ}C$

Type K: $\pm 0.8^{\circ}C$, $-275^{\circ}C$ to $1350^{\circ}C$

Type T: $\pm 0.3^{\circ}C$, $-275^{\circ}C$ to $400^{\circ}C$

Type E: $\pm 0.8^{\circ}C$, $-275^{\circ}C$ to $1000^{\circ}C$

Type R: $\pm 0.8^{\circ}C$, $0^{\circ}C$ to $1750^{\circ}C$

Type S: $\pm 0.8^{\circ}C$, $0^{\circ}C$ to $1750^{\circ}C$

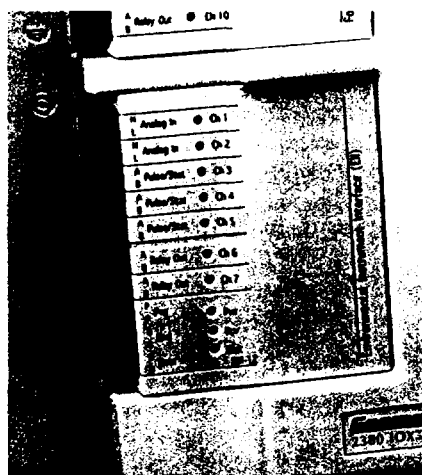
Labeling: Ch 1, Ch 2, ... Ch 10; two terminals per channel labeled H, L

Indicators: One LED for each channel; LED lights when channel is addressed for measurement or excitation

Connectors: 3.5mm pitch screw-clamp terminals (20 terminals per Module)

Wire Size: 28 to 14 AWG

EII — Environmental Instrument Interface



General Description —

The Environmental Instrument Interface (EII) I/O Module combines an SDI-12 environmental instrument communications port with Analog Inputs, Pulse/Status Inputs, and Form A Relay Outputs. The EII is similar to the Multi-Function I/O (MIO) Module in that it contains channel-types that are replicated on other modules, namely the ASM, PSI, and ARO. In addition to monitoring environmental instruments, the EII is appropriate for controlling external devices and equipment based on measured parameters when using one or more SDI-12 low-power intelligent sensors. With the exception of the SDI-12 communications port, the EII implements channel types that are fully described and specified for other I/O Modules.

The SDI-12 Interface —

SDI-12 is a voluntary industry standard for interfacing data recorders with microprocessor-based sensors. The merits and limitations of this interface have resulted in industry support being focused around manufacturers of battery powered environmental sensors and data loggers. The predominant emphasis on the SDI-12 interface is the interchangeability of sensors and sensor types for battery powered, field deployed instruments. The standard was originally motivated by the U.S. Geological

Survey for applications with the following requirements:

- Battery powered operation with minimal current drain
- Low system cost
- Use of a single data recorder with multiple sensors on one cable
- Up to 200 feet of cable between a sensor and a data recorder, with transient immunity

Typical Applications —

- Inflow and infiltration studies for water utilities and water resources organizations
- Automatic data collection for hydrographic stations
- Water quality monitoring networks using multi-parameter water quality probes with the SDI-12 interface
- Wastewater sampler control, based on user programmed conditions of water quality, time, flow, and rainfall

Specifications —

Channels: 7

Ports: 1 SDI-12

Channel Types —

2 Analog Input: See ASM description and specifications

3 Pulse/Status Input: See PSI description and specifications

2 Relay Output: See ARO description and specifications

SDI-12 Port Specifications —

Port Type: SDI-12 Data Recorder Signal Lines —

Data: Serial, bi-directional, 3-state

Power: 9.6V–16V, software switched

Ground: Common to power and data

Transient Suppression —

I/O Channels: ASM, PSI, ARO, EXO specifications apply

Port: SDI-12 specifications apply

Labeling —

Ch 1, Ch 2: H, L, Analog In

Ch 3, Ch 4, Ch 5: A, B, Pulse/Stat

Ch 6, Ch 7: A, B, Relay Out

SDI-12 Port: Terminals: P, P, Pwr; G, G, Gnd; D, D, Data. LEDs: Pwr, Rcv, Xmt

I/O MODELS (continued)

Indicators —

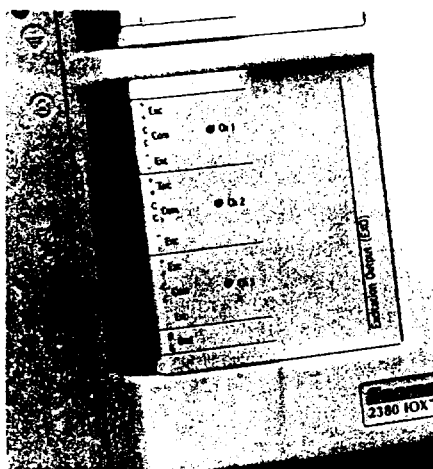
One LED Per Channel: Channels 1–7, LEDs functions same as respective ASM, PSI, ARO channels

Port LEDs: Pwr lights when power is applied; Rcv and Xmt blink during transmit; Rcv blinks during receive

Connectors: 3.5mm pitch screw-clamp terminals (20 per module)

Wire Size: 28 to 14 AWG

EXO — Excitation Output



General Description —

The primary purpose of the EXO Module is to provide isolated and regulated excitation to external instruments and sensors. The fundamental differences between the excitation provided by the EXO and voltage-mode excitation resources built into the MCU and available at Analog Input channels (on the ASM, MIO, and EII) are the following:

1. The EXO provides *low source-impedance* outputs capable of delivering relatively high power to the wiring terminals. A low source-impedance cannot be provided through the small-signal multiplexer switches on Analog Input type channels. The “stiff” output from the EXO can therefore provide the power and regulation typically required by external analog sensors whose measurement performance depends on both short- and long-term DC power supply stability.

2. EXO outputs are derived from plug-in DC/DC converter modules, providing *isolation from all circuitry* in the MCU. The isolation is necessary in the general case to prevent ground loops or other unintended signal interactions that would otherwise convert to significant measurement errors.
3. EXO outputs do not tie up MCU measurement resources. Therefore, no restrictions apply to the duty cycle.

Excitation Power Supply (EPS) Options —

An EXO Module can accept from one to three optional plug-in Excitation Power Supplies (EPSs). An EXO must contain at least one EPS to function. EPS outputs are independently controlled by user programming in the MCU. All output voltages that are normally required for sensor or instrument excitation are available in the set of EPSs offered. The following lists the Model Numbers and Descriptions for EPS options:

- EPS-5S+5V Excitation Power Supply for EXO
- EPS-5D±5V (or 10V) Excitation Power Supply for EXO
- EPS-12D±12V (or 24V) Excitation Power Supply for EXO
- EPS-15D±15V (or 30V) Excitation Power Supply for EXO

Typical Applications —

- Turn-on of remote equipment under MCU program control, in installations with limited power budgets
- Power-strobed remote sensor excitation, with high isolation and stability

Specifications —

Channels: 3

Type: Isolated single or dual regulated voltage outputs

Control: Independent on, off, or pulsed on; software controlled

Output Power: 3 watts per channel

Output Voltages Available: By pluggable DC/DC converters: 5V, 10V, 24V, 30V, ±5V, ±12V, ±15V

Operating Temperature Range: -25°C to +70°C

Regulation: ±2% of output (1/4 – full load) ±0.05%/C°

Ripple & Noise: 100mVp-p (DC–20 MHz)

Short Circuit Protection: Short-term, self-recovering

Input–Output Isolation: 500VDC

Transient Suppression: 15V suppressor diodes across each supply, 600W peak power

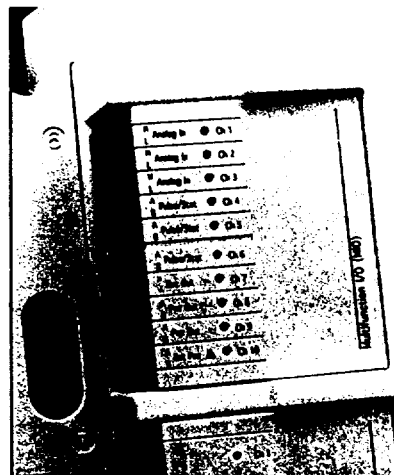
Labeling: Ch 1, Ch 2, Ch 3; 6 terminals per channel: dual COM, +EXC, –EXC per channel

Indicators: One LED per channel; LED is on when the channel is activated

Connectors: 3.5mm pitch screw-clamp terminals (20 per module)

Wire Size: 28 to 14 AWG

MIO — Multi-Function I/O



General Description —

The Multi-Function I/O Module provides a combination of Analog and Pulse/Status Inputs with Excitation and Form A Relay Outputs. The MIO combines channel-types that are replicated on the ASM, PSI, EXO, and ARO Modules. The particular mix of channels on the MIO have been selected to allow economical implementation of closed-loop control for a range of applications with a single I/O Module.

With two exceptions, the MIO implements channel types that are fully described and specified for other I/O Modules. One exception is that the MIO contains an External Power input on Channel 10 that can be switched through ARO type relays on

I/O MODELS (continued)

Channels 8 and 9. This provides a convenient way to route a control signal required to activate external devices such as solenoids or relays controlling valves or gate actuators. The other exception is that the Exc Out (Ch 7) on the MIO is unipolar only, and does not provide for an optional bipolar connection as implemented on the EXO Module.

Excitation Power Supply (EPS) Option —

Use of the Exc Out provided on Ch 7 requires the selection of an optional plug-in Excitation Power Supply (EPS). This is the same set of DC/DC converter modules used with the EXO module. However, only unipolar configurations are available through the 2-terminal Exc Out channel on the MIO. The EPS output is independently controlled by user programming in the MCU. The following lists the Model Numbers and Descriptions for EPS options as they relate to use on the MIO:

- **EPS-5S:** +5V Excitation Power Supply for MIO
- **EPS-5D:** 10V Excitation Power Supply for MIO
- **EPS-12D:** 24V Excitation Power Supply for MIO
- **EPS-15D:** 30V Excitation Power Supply for MIO

Typical Applications —

- Gate control in open-channel canals, measuring upstream/downstream levels and gate position
- Wide-area flow regulation for irrigation canal operations, with user developed feed-forward control algorithms
- Valve control, based on user programmed algorithms using pressure and flow input parameters

Specifications —

Channels: 10

Types —

3 Analog Input: See ASM description and specifications

3 Pulse/Status Input: See PSI description and specifications

1 Excitation Output: See EXO description and specifications, 2-terminal only: +V, COM or +V, -V

2 Power or Relay Outputs (Selectable Modes Per Channel) —

Mode 1 – Form A Relay Output: See ARO description and specifications

Mode 2 – Switched Power: Supplied by the input to Channel 10

1 External Power Input: AC/DC: $\pm 60V$ peak, 2A current limit

Transient Suppression: ASM, PSI, ARO, EXO specifications apply

Labeling —

Ch 1, Ch 2, Ch 3: H, L, Analog In

Ch 4, Ch 5, Ch 6: A, B, Pulse/Stat

Ch 7: +, -, Exc Out

Ch 8, Ch 9: A, B, Pwr Out

Ch 10: A, B, Ext Pwr D

Indicators —

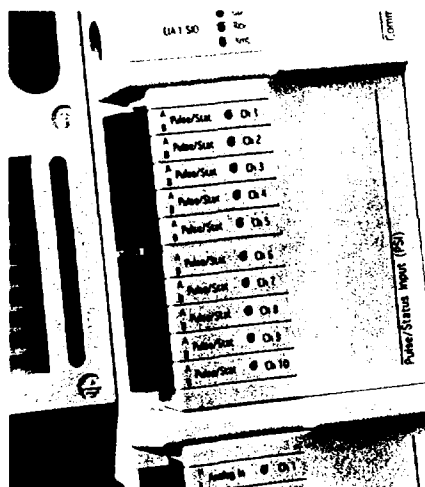
One LED Per Channel: Channels 1–9: LEDs functions same as respective ASM, PSI, ARO, EXO channels

Ch 10 LED: Lights when input voltage exceeds $\pm 4V$ DC or AC

Connectors: 3.5mm pitch screw-clamp terminals (20 per module)

Wire Size: 28 to 14 AWG

PSI — Pulse/Status Input



General Description —

The PSI Module offers versatile capabilities for handling pulse rate, accumulator, and incremental counting functions. In addition, PSI channels can be used to detect, record and alarm status conditions and times of events. Ten input channels are replicated

on the Module, while allowing different channels to operate in different functional modes. Multiple operating modes extend flexibility and economical use of hardware resources. On-board microcontrollers and counters allow the low-power PSI to operate with full capability even when the MCU is in the sleep-state. In fact, the PSI can be programmed so that activity sensed by an input channel can wake the MCU for further processing.

Input conditioning features of PSI input channels allow direct wiring of unipolar signals from external devices. For voltage-level inputs, the detection threshold can be offset to prevent false triggering. Excitation is also provided for sensing external contact closures.

Typical Applications —

- Flow rate and accumulation from gas and liquid flow meters
- Energy monitoring from watt-hour meters
- Background-level radiation monitoring from particle detectors
- General event monitoring
- Equipment status and security monitoring

Specifications —

Channels: 10

Type: Voltage or contact closure inputs, software selectable

Voltage Inputs: Bi-polar or DC offset, software selectable

Input Impedance: 100k Ω

Detector: Threshold crossing with hysteresis

Threshold Levels: 0V or 1.65V, software selectable

Hysteresis: 10mV

Minimum On-Time / Off Time: 250 μ s

Pulse Rate: 0-1800/s

Contact Closures: Dry contact sensing

Sensing Signal: Pulsed 10V, 1mA

Contact De-Bounce: 8ms on / 8ms off

Functions —

Pulse Rate Functions: Instantaneous or average

Pulse Accumulator: 32-bit counter, continuous accumulation until reset

Incremental Counter: Counts occurring since last Evaluation

Status Input: On / off

I/O MODELS (continued)

Power Management Features: Any channel can be enabled to wake up the MCU when a transition occurs, and trigger Evaluations

Transient Suppression: 15V bi-directional suppressor diodes per input terminal, 600W peak power

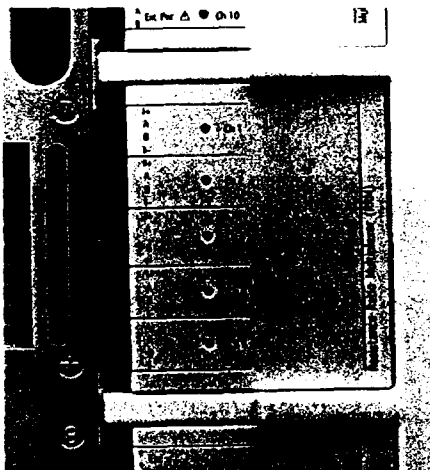
Labeling: Ch 1, Ch 2, ... Ch 10; two terminals per channel labeled A, B; the B terminals are MCU ground

Indicators: One LED for each channel; LED blinks when input transition occurs, to a maximum rate of 4/s

Connectors: 3.5mm pitch screw-clamp terminals (20 terminals per module)

Wire Size: 28 to 14 AWG

RRM — Resistance Ratio Multiplexer



General Description —

The RRM is a special purpose I/O Module for making multiplexed resistance or resistance ratio measurements on up to 5 channels with 3- or 4-wire configurations. The RRM operates in conjunction with MCU software to accurately measure low-resistance devices normally intended for measurement in a bridge completion circuit.

With low resistance sensing elements, the resistance of the leadwires introduces significant and usually unacceptable error if leadwire resistances are uncompensated. The leadwire configuration of these devices has

historically been determined by the leadwire resistance compensation technique used in a bridge completion network. Therefore, the leadwire configuration normally requires a bridge completion circuit for effective leadwire resistance compensation. However, per-channel bridge completion networks are not economical to implement or maintain calibration in multiplexed automatic data acquisition systems.

The optimal leadwire configuration for automatic data acquisition allows true 4-terminal (Kelvin) connections at the sensing resistance element, entirely excluding leadwire resistance errors from the measurement.

For devices that do not allow true Kelvin connections, such as 3-wire resistance devices, an accurate measurement can be made as long as one device node has 2 wires attached. The RRM is designed to make a Kelvin-type measurement at the resistance device node having two leads (for both a current terminal and a potential probe). The RRM measures the leadwire resistance through a multi-step sequence. For device nodes that do not have both a potential and current lead, resulting in an embedded leadwire resistance, the measured leadwire resistance from the other node is applied as a dynamic correction to the measured resistance. This embedded leadwire resistance compensation assumes that the current-carrying leads are the same resistance (same wire gauge).

The RRM can be connected to both one-element (3-wire) devices, normally used for temperature measurements, and 2-element (4-wire) devices, in which a resistance ratio measurement is normally used for strain measurements. The RRM, therefore, is specifically designed to accommodate automatic data acquisition retrofit for existing low-resistance devices for which it is impractical or prohibitively expensive to change the leadwire configuration to 4-terminal (Kelvin) connections.

Typical Applications —

- **Four-Wire Half-Bridges:** Carlson meters: resistance ratio strain measurements, total resistance temperature sensing
- **Four-Wire Potentiometers:** Potentiometric ratio with leadwire compensation and immunity to wiper-resistance
- **Three-Wire Resistive Sensors:** RTDs, resistance measurements with lead-wire compensation
- **Four-Wire Resistive Sensors:** RTDs, true Kelvin connections with leadwire error elimination

Fundamental Measurements & Excitation —

Multi-Mode Resistance: Half-bridge, quarter-bridge resistances and resistance ratios with lead wire compensation.

Ratiometric Resistance: See DC Measurement Subsystem / Resistance

Excitation: Voltage-mode with reference resistance in the MCU. See DC Measurement System / DC Excitation Source.

Specifications —

Channels: 5 analog, 4-wire

Terminal Configuration: Positive voltage excitation on I+ with return through I- and internal reference resistor. Voltage measurements from I+ to A, A to B, and B to I-

Switching Devices: Opto-coupled, low thermal offset MOSFET relays. Separately switched measurement and excitation.

Transient Suppression: High pulse-current suppressor diodes, 1500W peak power

DC Offset: <2μV differential

Excitation: +10V with 10KΩ return resistance, or 5V with 70Ω return resistance, autorange selected

Labeling: Ch1, Ch2, ... Ch5; four terminals per channel labeled I+, A, B, I-

Indicators: One LED for each channel; LED lights when channel is activated for excitation or measurement

Connectors: 3.5mm pitch screw-clamp terminals (20 terminals per Module)

Wire Size: 28 to 14 AWG

MCU OPTIONS AND ACCESSORIES

Flashdisk Mass Storage (FMS)



GENERAL DESCRIPTION

High capacity local data storage for the 2380 MCU is provided by an optional PCMCIA Flash Memory Card, which plugs into one of the two PCMCIA Type II sockets in the MCU. The 8 MB card, designated as the FMS-8, has a capacity of 160,000 logged measurements in GEONET format. The FMS-20 has a capacity of 400,000. These non-volatile memory cards are formatted for the 2380 MCU file system and GEONET. The cards operate over the full industrial temperature range of -40°C to +85°C.

In addition to high capacity, the "PC card" removable media has the advantages of being compact and field-rugged from an environmental and handling standpoint. PCMCIA compatibility allows the MCU to accommodate economical memory technologies developed for large markets.

DATA LOGGING

The obvious application for FMS options is stand-alone data logging with an individual MCU. However, beyond the isolated data logger, there are distributed data logging applications where measurements are spatially dispersed. In the distributed situation, multiple MCUs are field-networked to a single MCU, which receives data from all the MCUs and stores the data to a single

FMS Card. This configuration is particularly useful when some or most of the MCUs are not conveniently accessible for data retrieval. The user can retrieve data from multiple MCUs at the most convenient location.

BUFFERING FOR SHARED FACILITIES

Flashdisk Mass Storage is also used to buffer remote data in networked configurations that use public telephone, cellular, or satellite networks for data transport. Expanding on the field data logging situations described above, an MCU in a LAN or a Remote Area Network (RAN) can bridge to a Wide Area Network (WAN) through connections to public or private shared access facilities. Buffering large caches of data before transporting over shared access facilities allows more efficient and economical use of the facilities.

REDUNDANT DATA BACKUP

Many Geomation systems are used to collect critical data during particular events which cannot be repeated, either because they are natural events or else the result of measurements made under non-repeatable conditions. Even though on-line configurations are normally used for such applications, communication links or computers can fail, with potential loss of the critical data. The FMS option allows data to be written to MCU local mass storage, in addition to routine logging over network connections to GEONET. This provides economical operational redundancy for critical data collection applications.

MCU PROGRAMMING

MCU programming, for both instrumentation functions and network topology, can be transferred from GEONET to MCU(s) with an FMS card. The new 2380 MCU file system allows FMS cards to be used both for MCU configuration database storage/transfer as well as measurement data retrieval. Therefore, in manual data logging systems, any configuration modifications are delivered to MCUs in the process of exchanging FMS cards for data retrieval. This simplifies

logistics and skills for field data logging support, and eliminates the risk of taking a laptop computer to the field.

Communication Devices



Telephone Network Modem

MCUs support public telephone network connections through a PCMCIA Telephone Modem, designated as the TNM option. The modem plugs into one of the two PCMCIA Type II slots in the MCU. An FMS data storage option is normally used in conjunction with the TNM option for data buffering as described above. The FMS option plugs into the additional Type II slot.

The Hayes Optima 33.6 Modem included in the TNM option is used because of its capacity for superior power management by the MCU. It will operate at data rates to 28,800 bits/s when used with a 2380 MCU transferring data to GEONET Suite. The modem is fully configured by the MCU when the MCU is initially powered up.

If you plan to use the TNM option with telephone systems outside of North America, you should verify the compatibility of this modem type with your public telephone network. If there are further questions regarding compatibility with your telephone system, please contact Geomation Customer Service.

MCU OPTIONS AND ACCESSORIES (continued)

Radio Links

Reliability & Simplicity

UHF and VHF Radio Link options integrate tightly with the MCU mechanically and electrically. These radio links provide the most economical and reliable method of networking 2380 MCUs in virtually any field environment as well as in many plant environments. Dependable radio networking has been a long-standing hallmark of the Geomation System 2300. GEONET Communications Protocol (GCP) implemented in MCU software allows all radios to operate on the same frequency using Carrier-Sense Multiple-Access with Collision Avoidance (CSMA/CA). Since the same protocol is used for point-to-multipoint wireline connections, radio operation is identical to wireline operation.

Power & Range

These narrow-band radios are capable of relatively high RF output power (4 watts for UHF & 5 watts for VHF) providing a range of several kilometers, and even much farther with appropriate antenna systems. Since any MCU can be programmed as a repeater for GCP messages from other nodes, systems can be designed to clear terrain obstructions and multiply range to distant locations. The digital repeating feature is important in many field situations. Examples are large area installations over watersheds and municipalities, and extended river and canal reaches. In addition, Geomation can provide a linear amplifier option on special order to boost RF output power to 45 watts.

Due to the long range of signal propagation with these radio links, installations in most countries are governed by a regulatory authority. These authorities normally require users to obtain a location-restricted license in order to assure interference separation among different users of the RF spectrum.

Installations in the USA

For industrial and scientific applications in the U.S., customers may install and use radio linked systems on Geomation held licenses with radios limited to 2 watts of maximum output power. Other restrictions related to

antenna height and proximity to national borders apply. (Please contact the Geomation sales or service departments for more details.)

Option Configurations

The RL-EN is the version of the option which includes components for installation in the EN20, EN20-XC, the EN80 or the EN80-XC standard enclosures. This option consists of the radio transceiver itself, a dipole antenna, dummy load, MCU System Board interface card, System Board mounting bracket, a Coaxial Transient Arrestor (CTA), BNC bulkhead feedthru, and coaxial cables for internal installation in Type EN enclosures.

The RL-G version of the option includes everything included in the RL-EN option, plus the CTA Mounting Bracket with fastening hardware, and a 2m grounding cable. The RL-G is for MCUs installed in other enclosures or in buildings without enclosures. A 0.85m coaxial cable is provided with the RL-G to go from the radio output to the CTA. (This cable may need to be replaced or extended if it is not long enough for the installation conditions.)

Radio Links require factory installation for proper set up and adjustment with specialized test equipment. MCUs originally purchased without an RL option may be returned to Geomation for Radio Link installation.

Antennas & Cables

For relatively short range line-of-sight installations of a few of kilometers, the small dipole antenna included with the radio option will probably provide adequate signal strength for reliable communications. For longer range requirements, Geomation offers three high-quality UHF antenna options with different radiation patterns to provide suitable propagation characteristics for most field deployment topologies. Two omnidirectional antennas and one directional antenna are included in the antenna options described here. (VHF antenna options can be provided on special order.)

Omnidirectional Antennas

The Standard Omnidirectional Antenna (SOA) is a very rugged broadband collinear type covering the entire frequency range of 406-470 MHz. The radiator assembly is enclosed in a rugged fiberglass radome for maximum protection from severe weather, saltwater and corrosive atmosphere. Specifications: Impedance 50Ω; VSWR < 1.5:1; gain = 0 dB (ref. to the halfwave dipole). Vertical polarization. Input is a Type N female connector. Special construction provides complete weather-protection for the connector inside the supporting pipe. The alternate mounting also provides adequate protection. The SOA includes a cast aluminum mounting base and stainless steel V-bolts for mounting to pipes of 20-54 mm (3/4"-2-1/8") OD. Length: 515mm (20.3"). Net weight: 0.75 kg (1.65 lbs).

The SOA is appropriate for omnidirectional applications, that is, where the MCU needs to communicate with multiple network nodes at different azimuths. This antenna has been chosen because it is compact, rugged, easy to install, and relatively low cost.

The High-gain Omnidirectional Antenna (HOA-n) is a ruggedized precision collinear array design with 6 dB gain (over dipole). This antenna is provided tuned to any specified frequency in the range 406-500 MHz. The "-n" frequency code following the Model Designation specifies a frequency from the Table of Frequencies for Geomation FCC Licenses listed below. (See above - Installations in the USA.)

A unique parallel feed system eliminates phase lag between elements during icing, and thereby resists changes in pattern often encountered with other omni gain antennas under icing conditions. Specifications: Impedance 50Ω; VSWR < 1.3:1 at $F_c \pm 6$ MHz; Vertical polarization. Input is a Type N female connector. Two heavy anodized castings with stainless steel hardware are provided to attach the HOA to a vertical pipe mast with 2-3/8" maximum OD. Dimensions: 244cm x 12.7cm (96" x 5"), not including ground radials. Net weight: 6.36 kg (14 lbs).

MCU OPTIONS AND ACCESSORIES (continued)

The HOA is designed for use as a communications base station antenna. With the System 2300, it would normally be used with a radio Gateway MCU where high gain is required to communicate with distant remote sites that vary in azimuth. High gain in omnidirectional antennas results in increased size, weight and cost. Therefore, the SOA would be preferred for an omnidirectional radio gateway application if the higher gain provided by the HOA is not required by range and the need to overcome loss in the antenna cable.

Directional Antenna

The YAGI Directional Antenna

(YDA-n) is a five-element yagi designed for high performance and long-term reliability even under severe environmental conditions. This antenna is provided tuned to any specified frequency in the range 400-512 MHz. The "-n" frequency code following the Model Designation specifies a frequency from the Table of Frequencies for Geomation FCC Licenses listed below.

(See above - Installations in the USA.)

A balanced feed design provides equal distribution of energy to the driven element, and allows the entire antenna structure to be kept at DC ground potential. Specifications: Impedance 50Ω; VSWR < 1.3:1 at $F_c \pm 0.6\%$; gain = 10 dB (over dipole). Vertical or horizontal polarization. Input is a Type N female connector. Includes heavy aluminum castings and stainless steel hardware for mounting to 2-3/8" maximum OD circular support. Dimensions: 72.4cm x 33.5cm (28.5" x 13.2"). Net weight: 2.27 kg (5 lbs).

The YDA is appropriate for most remote MCU locations where the communication path is unidirectional. It should also be used for Gateway situations rather than an omnidirectional antenna if all communication with remote nodes is in the same direction. This antenna has been selected because of its quality construction and long term reliability.

Antenna Cables

Coaxial Antenna Cables are provided with connectors to go from the Coaxial Transient Arrestor (CTA) to any of the Antennas

Table of Frequencies for Geomation FCC Licenses (USA)	
-1	457.525MHz
-2	457.550MHz
-3	457.575MHz
-4	457.600MHz
-5	457.750MHz
-6	467.775MHz
-7	467.800MHz
-8	467.825MHz

described above. The CTA is included with the Radio Link options. Antenna Cables are specified separately to accommodate cable length variations between the MCU location and the antenna mounting.

The Standard Antenna Cable (SAC) is 2m in length and has an insertion loss of 0.3dB at 450MHz. This cable is supplied with factory installed connectors: a weatherproof Type N male connector on the antenna end, and a weatherproof BNC male connector on the CTA/Radio end. The SAC should be used for installations where the antenna is collocated with the MCU, and the cable does not have to pass through any openings smaller than 14.5mm (0.57") diameter, the clearance diameter for the smaller BNC connector.

The Extended Antenna Cable (EAC-nn) is ordered to the required length, where -nn specifies the cable length in meters. The EAC is a Times Microwave Systems LMR-240 cable with an attenuation of 0.174dB/m @ 450MHz. This cable is factory-terminated on one end with a weatherproof Type N male connector for the antenna connection. The other end of the cable is not terminated since extended cables are usually fed through a bulkhead cable fitting or a conduit. Therefore, the equipment end of the cable must be field-terminated with the supplied BNC male clamp type connector. The clamp type connector does not require specialized tools for termination. This cable has the benefit (compared with the LEAC-nn described below) of a smaller

diameter [6.1mm (0.240")] and minimum bend radius [19mm (0.75")]. However, the smaller diameter results in higher signal attenuation per unit length. For antenna cables longer than about 20m, it is recommended to use the Low-loss Extended Antenna Cable (LEAC-nn) described below.

The Low-loss Extended Antenna Cable (LEAC-nn) is ordered to the required length, where -nn specifies the cable length in meters. The LEAC is a Times Microwave Systems LMR-400 cable with an attenuation of 0.089dB/m @ 450MHz. This cable is terminated in the same way as the EAC, at one end only, allowing it to be pulled through conduit or cable fittings.

The LEAC has a diameter of 10.3mm (0.405") and a minimum bend radius of 25.4mm (1.0"). This low-loss cable should be used to reduce overall signal attenuation for longer extensions. A gain antenna can be used to overcome loss in the cable.

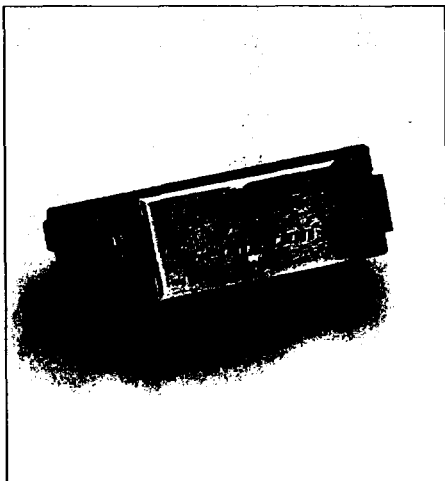
EIA2 RS-232 Adapter (SIO2)

The SIO2 provides the optional hardware to enable a second RS-232 communication port for the MCU, in addition to the built-in EIA 1 Serial I/O port. The option consists of an RS-232 PCMCIA card and a 3m cable terminated with a D9 connector with socket contacts. The supplied cable mates to a standard COM port on a PC.

An EIA 2 communication port is automatically enabled when the MCU is powered up with the SIO2 option plugged into either slot of the PCMCIA Adapter. The EIA 2 port supports point-to-point GEONET Communications Protocol (GCP) connections. The SIO2 provides an RS-232 interface only, whereas the EIA 1 port on the MCU provides both RS-232 and RS-485 electrical interfaces.

The primary application for the SIO2 is to allow a GEONET Gateway connection to the MCU through an EIA 2 port if the EIA 1 port is dedicated for another use, such as a Fieldbus Interface.

Transient Protection Devices



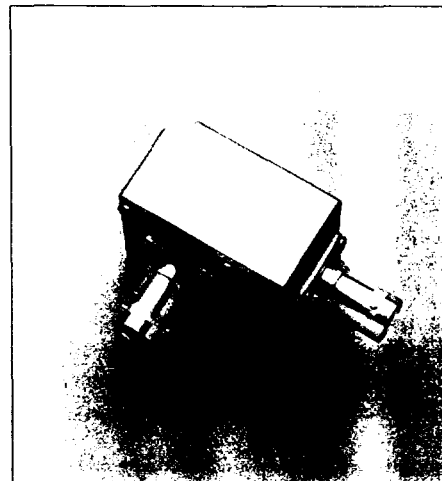
Multi-stage Transient Arrestor (MTA 2)

- ▶ Protects a single 2-wire circuit
- ▶ High input impedance; does not interfere with normal transducer signals
- ▶ Compact, low-profile package mounts on a standard DIN 35 rail
- ▶ Earth ground terminal engages the DIN mounting rail



Multi-stage Transient Arrestor (MTA 20)

- ▶ Protects up to ten 2-wire circuits
- ▶ High input impedance; does not interfere with normal transducer signals
- ▶ Compact, low-profile package mounts on a standard DIN 35 rail
- ▶ Earth ground terminal engages the DIN mounting rail



Coaxial Transient Arrestor (CTA)

- ▶ Protects low-power radio equipment
- ▶ Inserts into a coaxial antenna line
- ▶ Provides female BNC connectors
- ▶ Universal mounting bracket attaches to a vertical mast or a flat surface

Introduction

Surge voltages, or electrical transients, are induced from many types of sources into the wires and cables connected to electronic equipment. Common sources of these surges are the switching of large inductive electrical loads, such as motors, switching disturbances on the electric power grid, electrostatic discharges from human contact with connection terminals, and lightning discharges. These conducted transients pose a threat to electronic equipment of various types.

Electronic instrumentation is particularly susceptible because extended signal cables are often connected between sensing devices and the measuring equipment. The earth ground potential difference between the spatially separated endpoints is often driven momentarily to extremes. In addition, nearby atmospheric discharges, or the more violent ground strikes, induce high voltage

transients into the cable itself, acting as an antenna. No matter what the mechanism, without effective transient protection, a high voltage pulse results between the equipment terminals and the chassis ground to which the electronic components in the equipment are referenced. Many electronic components are damaged by these high voltage pulses.

The circuits in electronic measuring devices are especially susceptible to damage from transients because they generally employ highly integrated components with a low dielectric breakdown voltage. In addition, a direct electrical connection from the outside world must usually be made to these devices for the measurement circuits to work properly. The most troublesome aspect of measurement circuits is that most approaches to transient protection tend to interfere with the measurement itself conducted between the sensing device and the measuring system.

The MTA Series transient protection devices manufactured by Geomation are designed to provide robust multi-stage protection for both field devices (sensors, transducers and instruments) and measuring equipment such as data loggers, RTUs and MCUs. In addition, they are designed to provide this protection in a way that does not interfere with most low- or high-level measurement circuits.

The MTA 2 and MTA 20 Multi-stage Transient Arrestors are general purpose devices, designed for cabled primary measurements consisting of DC voltage, resistance, current, or frequency signaling over a low-frequency bandpass.

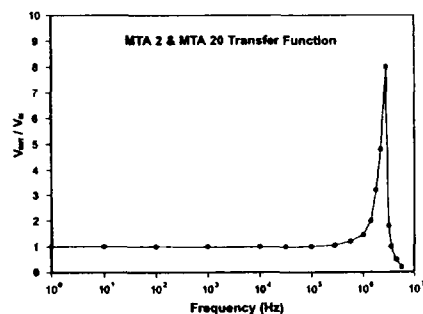
The CTA is designed to protect low-power VHF and UHF radio equipment from transients conducted through antenna systems.

Theory of Operation

The MTA Series devices are designed to quench high-energy transients conducted in a common-mode from the field side wiring without interfering with the measurement signals passed through during normal operation. High-frequency components of the transient waveform are impeded by a series inductor, allowing a fairly slow-acting but high current carrying capacity gas tube to shunt the most potentially damaging energy to ground, ahead of the inductor. The residual over-voltage energy that passes through the inductor beyond the initial stage is clamped to ground by a very fast-acting suppressor diode. The inductor serves to decouple the two stages.

As long as the surge does not exceed the current carrying capacity of the components described here, there is virtually no energy left that will damage equipment beyond the suppressor diode stage, as long as the suppressor diode clamping voltage is below the level which will cause damage to the protected equipment. Every terminal pair, field-side to protected-side, has the same common-mode circuit on both the MTA 2 and the MTA 20. In addition, the MTA 2 has a normal-mode suppressor diode between the paired circuits at the second stage. (See the Specifications below for common-mode and normal-mode operating ranges.)

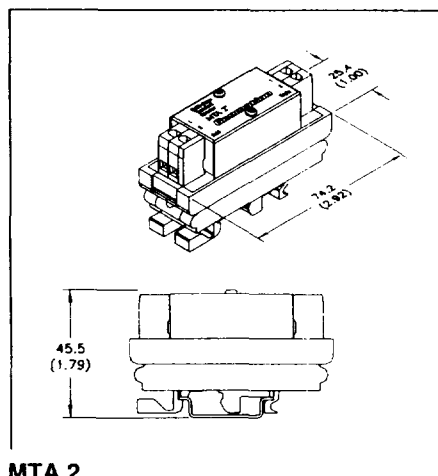
The CTA operates similarly to the MTAs, in that the most potentially damaging energy is forced to conduct through a gas discharge tube to ground. However, this device is designed to pass RF energy, of relatively high power content, with minimum loss and signal distortion. Since the device only needs to pass AC, and a series inductor would block the RF signal, a series capacitor is used to block the DC component of a surge. A following suppressor diode cannot be used since the relatively high shunt capacitance would distort RF signals. However, the RF input of the radio equipment is designed with circuits that can tolerate the residual transient from the single-stage CTA.



Specifications

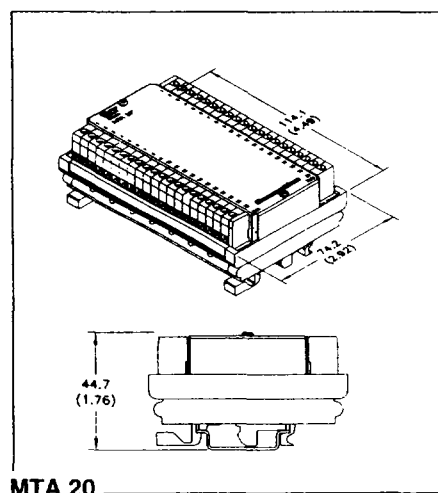
MTA 2

Peak Pulse Current –
(8/20 μ s pulse; 10 pulses): ± 5 kA
Max. Clamping Voltage –
(8/20 μ s pulse): ± 62 V common-mode,
 ± 54 V normal-mode
Suppressor Diode Firing Voltage –
Common-mode: ± 38 V min., ± 48 V max.
Normal-mode: ± 33 V min., ± 41 V max.
Application Voltage Limit –
Common-mode: ± 34 V min.
Normal-mode: ± 30 V min.
Series Resistance: 0.2Ω max.
Continuous Current: ± 2 A max.
Shunt Capacitance –
Normal-mode: 600 pF
Common-mode: 850 pF
Wiring Terminals –
Type: screw-clamp compression
Wire Size: 24–12 AWG
Operating Temperature: -55°C to $+100^\circ\text{C}$
Shipping Weight: 0.5 kg (1.0 lb)



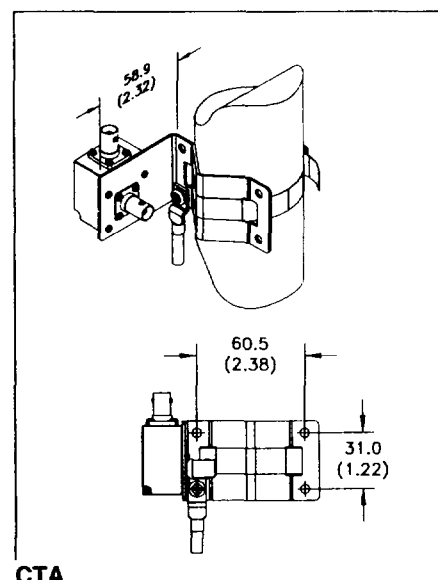
MTA 20

Peak Pulse Current –
(8/20 μ s pulse; 10 pulses): ± 5 kA
Max. Clamping Voltage –
(8/20 μ s pulse): ± 62 V common-mode,
 ± 124 V normal-mode
Suppressor Diode Firing Voltage –
Common-mode: ± 38 V min., ± 48 V max.
Normal-mode: ± 76 V min., ± 96 V max.
Application Voltage Limit –
Common-mode: ± 34 V min.
Normal-mode: ± 68 V min.
Series Resistance: 0.2Ω max.
Continuous Current: ± 2 A max.
Shunt Capacitance –
Normal-mode: 450 pF
Common-mode: 850 pF
Wiring Terminals –
Type: screw-clamp compression
Wire Size: 24–12 AWG
Operating Temperature: -55°C to $+100^\circ\text{C}$
Shipping Weight: 0.9 kg (2.0 lb)



CTA

Protector Type: DC blocking, gas tube shunt
Frequency Range: 100 MHz – 500 MHz
Max. RF Power –
100 MHz: 50 W
500 MHz: 25 W
Insertion Loss: 0.4dB max
Peak Pulse Current –
(8/20 μ s pulse; 10 pulses): ± 5 kA
Shunt Sparkover Voltage –
(1 kV/ μ s pulse): 600 V
Response Time –
(1 kV/ μ s pulse): 75 ms
VSWR: 1.3 : 1 max.
Connector Type: BNC Female
Operating Temperature: -55°C to $+125^\circ\text{C}$
Included Accessories: Universal Mounting bracket with fasteners, circular mast clamp, 2.3 m grounding cable
Shipping Weight: 0.9 kg (2.0 lb)



Geomation
A Division of the GE Group

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Tel: 720-746-0100
Fax: 720-746-1100
E-mail: info@geomation.com

ACTION PAK® AP4390/AP4391/ AP4392 MODEL



Benefits

- High Density 2-Channel Package Minimizes Installation Space
- Eliminates Ground Loops with 1500V Input-to-Output, Channel-to-Channel Isolation
- Easy Field Configurable Input Ranges: 10mV to 100V, 1mA to 100mA
- Six (6) Configurable Output Ranges: 0-5V, 0-10V, 0-1mA, 4-20mA, -5 to 5V and -10 to 10V
- Easy Plug-in Installation/ Low Mean-Time-to-Repair
- Selectable 120/240 VAC Power
- Lifetime Warranty



DC Input, Dual Channel Isolators

Provides Two Independent, Fully Isolated DC Outputs in Proportion to Two DC Inputs

DESCRIPTION

The field configurable AP4390 series dual channel isolators offer wide ranging input and output capability for scaling and transmitting analog DC signals. The AP4390 series will accept input voltage spans from 10mV up to 100 volts, as well as input current spans from 1mA to 100mA. For a full scale output range, the input zero and span potentiometers enable 50% input zero and span adjustability. For example, the 0-10V input range can be elevated to 5-10V or compressed to 0-5V.

The AP4390 series offers six (6) popular output ranges which are either positive voltages and currents (e.g. 0-5V, 0-10V, 0-1mA and 4-20mA) or bipolar voltages (-5 to 5V and -10 to 10V). The model number defines the output channel ranges as shown in Table 1.

Model	Input Range	Output Range
AP4390	0-10V	0-10V
AP4391	0-10V	0-1mA
AP4392	0-10V	4-20mA
AP4393	0-10V	-5 to 5V
AP4394	0-10V	-10 to 10V
AP4395	0-10V	0-10V

The 4-20mA compliance is a powerful 20VDC per channel. All models in the AP4390 series accept bipolar inputs and each I/O channel offers selectable normal or reverse acting operation (e.g. 4-20mA or 20-4mA).

Each Action Pak in the AP4390 series is a dual, three-port, industrial isolator -- both output channels are optically isolated from their respective input channels up to 1500 VDC. The two

ACTION
INSTRUMENTS

Protecting the
Integrity of
Industrial
Process Signals

INVERSO
ANALOG SYSTEMS

APPLICATION

The Action Pak AP4390 series of field configurable isolators is useful in eliminating ground loops, converting signal levels and providing signal drive. The AP4390 series' dual channel design conserves installation space in high density applications and offers superior cost-benefit value over single channel isolators. The wide ranging capability of the AP4390s provides universal spare part coverage.

DIAGNOSTIC LED

The AP4390 series is equipped with dual function LED signal monitors. The green, top-mounted LED indicates line power and input signal status. Active line power is indicated by an illuminated LED. If the input signal is 10% above the full scale range, the LED will flash at 8Hz. Below 0%, the flash rate is 4Hz.

OPTION

Urethane coating of internal circuitry for protection from corrosive atmospheres.

CONFIGURATION

Each channel of the AP4390 series can be independently set for a wide variety of input and output ranges.

FACTORY PRESETS

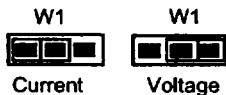
The factory presets all inputs for 4-20mA. The preset for positive based output channels is 4-20mA and -10 to 10VDC for bipolar voltage output channels (as shown in Table 1 and Figures 1 and 2). The supply power is configured for 120 VAC operation. For other I/O ranges, remove the four base screws and case to access the I/O cards.

Refer to figures 1 & 2 for configuration and program the I/O channels as desired.

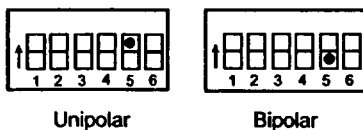
Replace the cover before applying power.

INPUT

1. Position input jumper "W1" for Current (I) or Voltage (V) input.

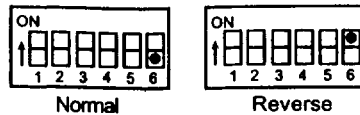


2. Set position 5 of the Input Range Selector for Unipolar or Bipolar input operation.



3. Set position 6 of the Input Range Selector for Normal or Reverse operation. Reverse

acting produces a decreasing output with an increasing input.

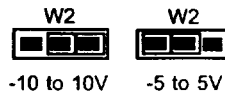


4. Using Table 2, configure positions 1 through 4 of the Input Range Selector for the desired maximum input. Round the desired maximum input value to the next highest range (e.g., 0-70V = 100V range).

OUTPUT

1. For the AP4390 channels A and B, and the AP4391 channel B, use Table 3 to configure the output selector switches for one of the four(4) standard output ranges.

2. For the AP4392 channels A and B, and the AP4391 channel B, position output jumper "W2" for -5 to 5V or -10 to 10V.



POWER

1. Configure the AC jumpers for either 120 or 240 VAC operation. See Figure 3.

CALIBRATION

1. Connect the input to a calibrated DC voltage or current source and apply power. Refer to PIN CONNECTIONS. Wait 1 hour for thermal stability before monitoring the voltage/current output.

2. Set the calibrator to the desired minimum input and adjust the Zero potentiometer for the desired minimum output.

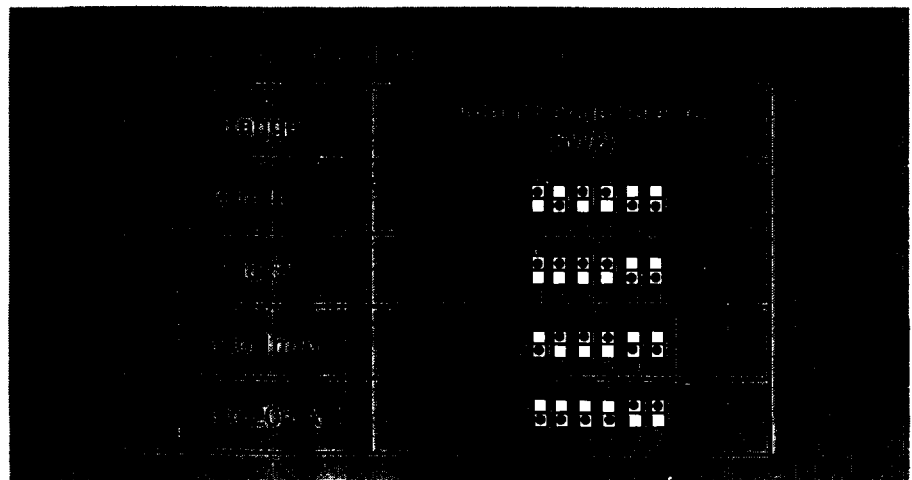
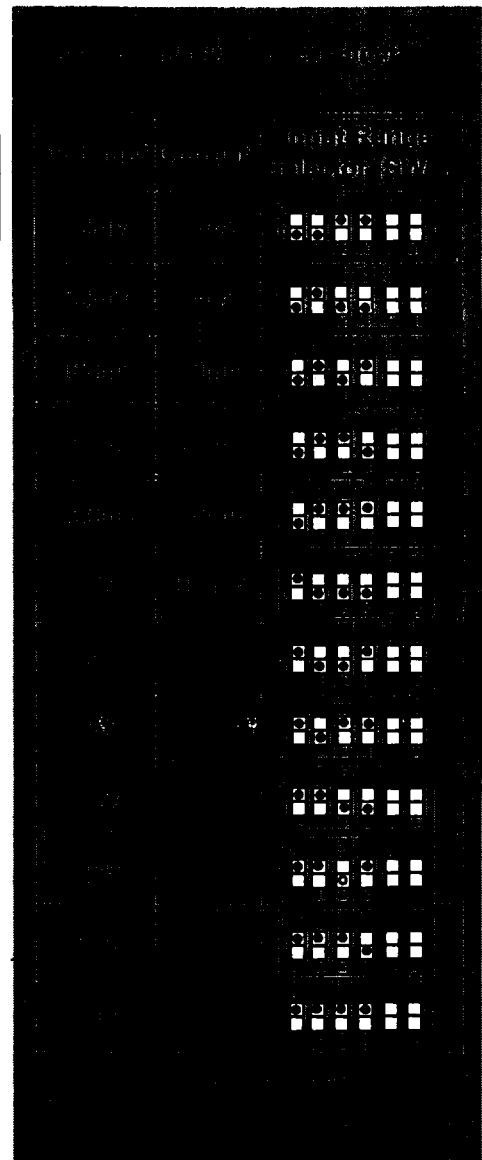
3. Set the calibrator to the desired maximum input and adjust the Span potentiometer for the desired maximum output.

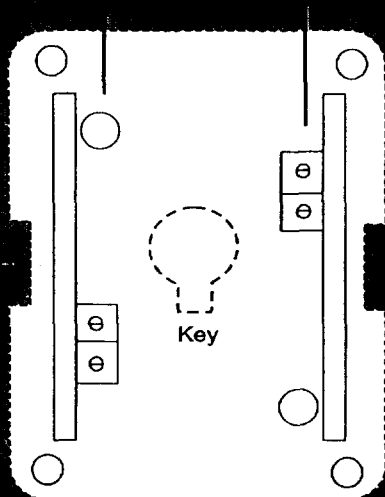
4. Repeat steps 2 and 3 for best accuracy.

FACTORY ASSISTANCE

For additional information on calibration, operation and installation please contact Action's Technical Services Group. Call toll-free:

800-767-5726





WARNING: Do not change with power connected!

MODELS & ACCESSORIES

Mounting

All Action Paks feature plug-in installation. Models AP4390, AP4391 and AP4392 use an 11-pin base and either molded socket M011 or DIN socket MD11 for mounting.

Ordering Information

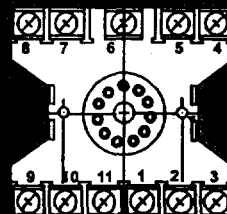
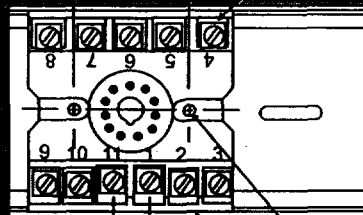
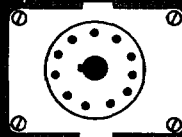
Specify:

1. Model: AP4390, AP4391 or AP4392
2. Option: U, see text
3. Line Power: 120/240VAC
4. Optional Factory Calibration (C620): specify input range, output range and power.

(All power supplies are transformer-isolated from the internal circuitry.)

Pin Connections

- 1 Power (Hot)
- 2 Spare Termination
- 3 Power (Neu)
- 4 Output B (+)
- 5 Input A (+)
- 6 Input A (-)
- 7 Output A (+)
- 8 Output A (-)
- 9 Output B (-)
- 10 Input B (+)
- 11 Input B (-)



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www.eurothermaction.com

www.actionio.com



ACTION INSTRUMENTS
—the Industrial I/O Company

ACTION PAK®



Ben

■ Hig
Pac
Inst

■ Elir
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Out
Cha

■ Eas
Inp
10C

■ Six
Rar
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-10

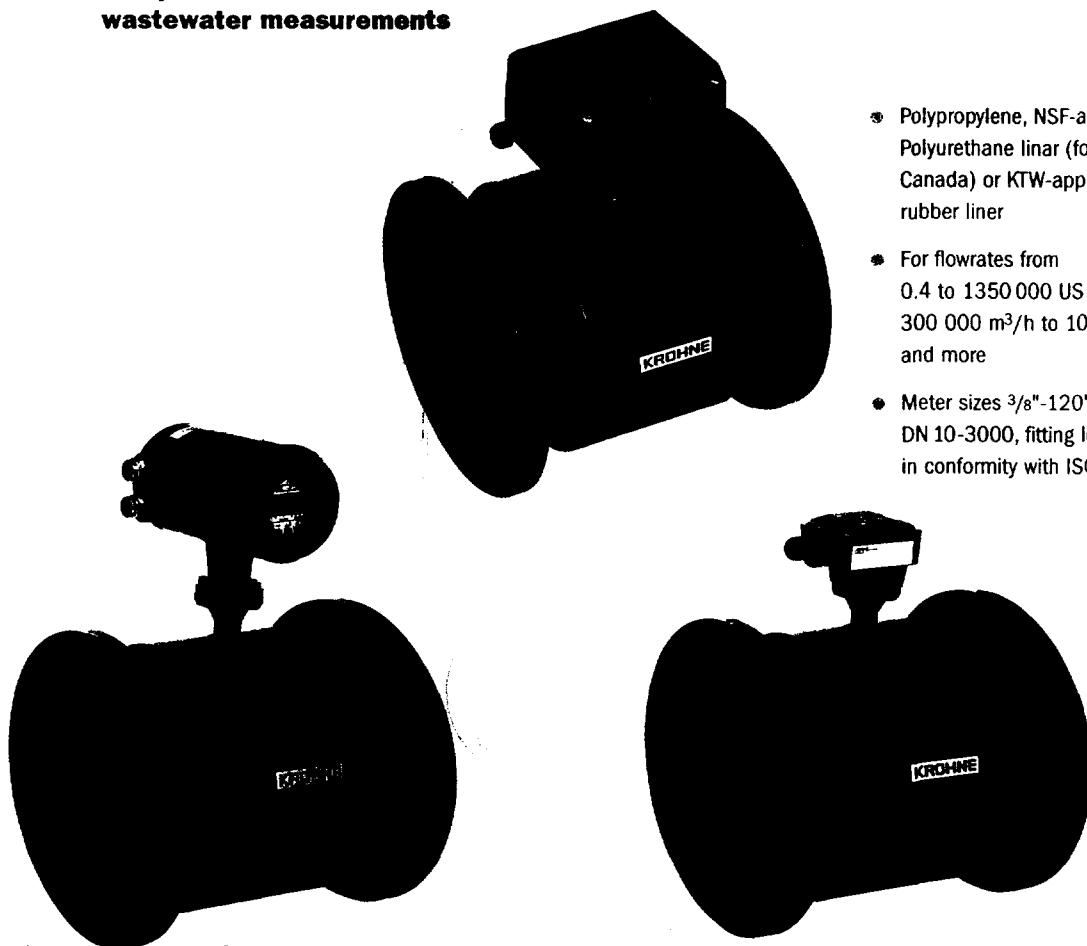
■ Eas
Lov

■ Selc
Box

■ Life

AQUAFLUX Electromagnetic Flowmeters

... the specialist for water and
wastewater measurements



- Polypropylene, NSF-approved Polyurethane linar (for USA and Canada) or KTW-approved hard rubber liner
- For flowrates from 0.4 to 1350 000 US Gal/min or 300 000 m³/h to 10 l/h and more
- Meter sizes 3/8"-120" and DN 10-3000, fitting length also in conformity with ISO

Variable area flowmeters

Vortex flowmeters

Flow controllers

Electromagnetic flowmeters

Ultrasonic flowmeters

Mass flowmeters

Level measuring instruments

Communications engineering

Engineering systems & solutions



AQUAFLUX

flowmeters measure the volumetric flowrate of electrically conductive liquids.

Applications

- Water and wastewater
- Environmental engineering
- Adequate abrasion resistance
- Chemical resistance:
alkaline solutions (e.g. NaOH)
up to 50% at 68°F / 20°C
acids (e.g. HNO₃)
up to 5% at 68°F / 20°C

Calibrated on **EN 45 001**
certified calibration rigs,
accuracy of calibration better
than 99.97% of the measured value.



AQUAFLUX Electromagnetic Flowmeters

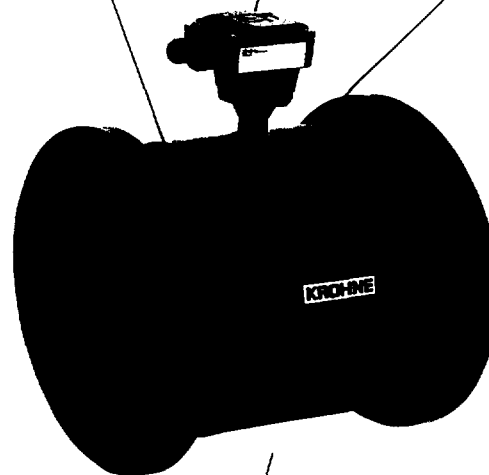
– the specialists for water and wastewater

Modular design:

- Remote version
with connection box, signal
converter in field housing or
as 19" plug-in version
- Integral version,
various signal converters
available for direct mounting
on the primary head

NEMA 6 as standard,
equivalent to IP 67,
(IP 68 on request),
permanently submersible,
suitable for ground burial

Fully welded housing,
extremely tight, rugged,
resistant to corrosion



For flowrates from 0.4 to 1350 000 US Gal/min
or 10 l/h to 300 000 m³/h and more

Meter sizes 3/8"-120" and DN 10-3000,
fitting length also in conformity with ISO

Technical data**Meter sizes**

Integral systems
AQUAFLUX F (remote)

$\frac{3}{8}$ " - 64" and DN 10 - 1600
 $\frac{3}{8}$ " - 120" and DN 10 - 3000

Pipe flanges

to ANSI B 16.5
to AWWA
to DIN 2501 (= BS 4504)

$\frac{3}{8}$ " - 24" / Class 150 lb / RF
14" - 120" / Class B or D / FF
DN 10 - 50 and DN 80 / PN 40
DN 65 and DN 100 - 150 / PN 16
DN 200 - 1000 / PN 10
DN 1100 - 2000 / PN 6
DN 2200 - 3000 / PN 2.5

Electrical conductivity

$\geq 20 \mu\text{S/cm}$

Temperatures

Integral systems

Ambient temperature	Process temperature
- 13 to + 140°F	+ 23 to \leq + 140°F
- 25 to + 60°C	- 25 to \leq + 60°C
- 13 to + 104°F	+ 23 to \leq + 194°F
- 25 to + 140°C	- 25 to \leq + 290°C
- 13 to + 140°F	+ 23 to \leq + 194°F
- 25 to + 60°C	- 25 to \leq + 290°C

AQUAFLUX F (remote)

Max. allowable operating data

Process temperature, operating pressure and vacuum load for the liner, refer to Page 6 "Limits"

Insulation class of field coils

E

Electrode design

$\frac{3}{8}$ " - 120" / DN 10 - 3000
Option 14" - 120" / DN 350 - 3000

flat elliptical electrodes, solidly fitted, surface-polished
field-replaceable electrodes WE

Protection category (EN 60 529 / IEC 529)

Standard

NEMA 6, equivalent to IP67
(with field replaceable electrodes WE: NEMA 4/4X, equivalent to IP65)
NEMA 6, equivalent to IP68

Option

Grounding rings

available as an option

Materials**Measuring tube**

Liner
 $\frac{3}{8}$ " - $\frac{3}{4}$ " / DN 10 - 20
1" - 6" / DN 25 - 150
8" - 120" / DN 200 - 3000

stainless steel SS 304 (or higher materials number), equivalent to 1.4301

Electrodes

Standard
Option
Field replaceable WE

Teflon®-PTFE
Polypropylene
hard rubber, Polyurethane

Connecting flanges*

ANSI
DIN: DN 10 - 50, DN 80 ($\frac{3}{8}$ " - 2", 3")
DIN: DN 65, \geq DN 100 (\geq 4")

Hastelloy C4
stainless steel SS 316 Ti or 1.4571, titanium
stainless steel SS 316 Ti or 1.4571

Housing*

$\frac{3}{8}$ " - $1\frac{1}{2}$ " / DN 10 - 40
 \geq 2" / \geq DN 50 /

steel ASTM A 105N
steel 1.0402 (C 22) or AISI C 1020
steel 1.0501 (RST 37.2) or AISI C 1035

Terminal box*

AQUAFLUX F (remote)

GTW-S 30 (malleable cast iron)
sheet steel

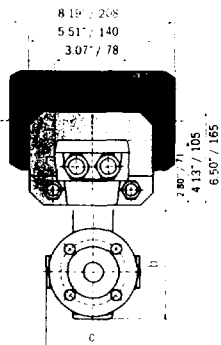
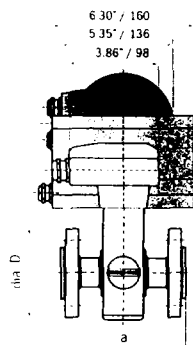
Grounding rings (option)

die-cast aluminium
stainless steel SS 316 Ti or 1.4571

* with polyurethane coating

Teflon® is a registered trademark of DuPont

3/8" - 1 1/2" / DN 10 - 40



Tolerance details for fitting length dimensions "a"

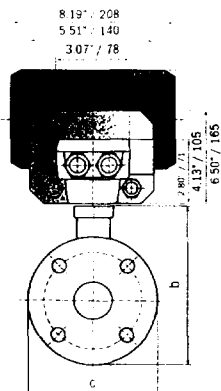
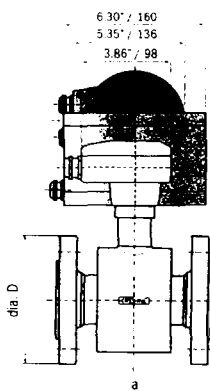
Standard

$\leq 12" / DN \leq 300 : \pm 0.5\%$
 $\text{min. } \pm 0.04" / \pm 1 \text{ mm}$
 $\geq 14" / DN \geq 350 : \pm 0.5\%$

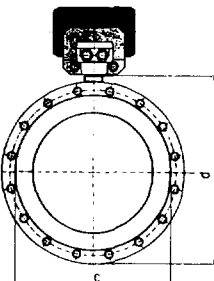
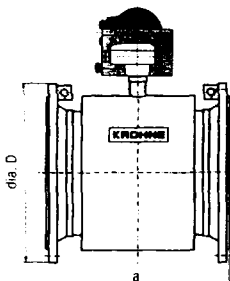
to ISO DIS 13 359

$\leq 8" / DN \leq 200 : +0/-3; 0/-0.12"$
 $\geq 10" / DN \geq 250 : +0/-5; 0/-0.20"$

2" - 12" / DN 50 - 300



14" - 24" / DN 350 - 1000



Dimensions $\geq 28" / \geq DN 1200$ on request

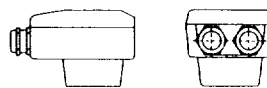
Dimensions and weights

PLEASE NOTE !

The **total dimension for the height** is obtained from **dimension b** (see table) **plus the height** of the terminal box or the signal converter, see drawings.

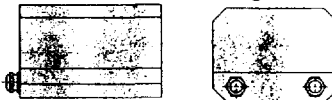
The **total weight** is made up of the weight of the signal converter (see table) **plus the weight** of the terminal box or signal converter, see below.

Terminal box



Weight approx. 1.1 lb / 0.5 kg

IFC 010 K and IFC 020 K signal converter



Weight approx. 3.6 lb / 1.6 kg

IFC 090 K signal converter



Weight approx. 5.1 lb / 2.3 kg

Flange connections to ...

ANSI B 16.5 3/8"-24" 150 lb / RF
≥ 300 lb / RF

AWWA ≥ 14" Class B, D / FF

DIN 2501 DN 10- 300 PN40, 16, 10
(= BS 4504) DN350-1000 PN10
DN350-1000 PN25

≥ DN1200 PN6, 2.5

Dimensions
in inches/mm
see table
dimensions supplied
on request
dimensions supplied
on request
see table
see table
see table,
dimension
"a_{standard}" + 200 mm
information supplied
on request

- * Dimension "a" without flange gaskets:
not included with flowmeter, to be provided by customer.
- * Meter size 3/8": flange connection 1/2"

Nominal size		Dimensions in inches/mm						Approx. weight in lb / kg	
ANSI	DIN	a fitting (length)		b		c	dia. D	with ANSI	with DIN
inches	DN	PN / psig	ANSI	DIN	ISO 13 359		ANSI	flanges	flanges
3/8	10	40 / 580	5.91 / 150	5.91 / 150	-	6.50 / 165	4.76 / 121	3.50 / 88.9	3.54 / 90
1/2	15	40 / 580	5.91 / 150	5.91 / 150	7.87 / 200	6.50 / 165	4.76 / 121	3.50 / 88.9	3.74 / 95
3/4	20	40 / 580	5.91 / 150	5.91 / 150	7.87 / 200	6.50 / 165	4.76 / 121	3.88 / 98.6	4.13 / 105
1	25	40 / 580	5.91 / 150	5.91 / 150	7.87 / 200	6.50 / 165	4.76 / 121	4.25 / 108	4.53 / 115
-	32	40 / 580	-	5.91 / 150	7.87 / 200	7.09 / 180	5.47 / 139	-	5.51 / 140
1 1/2	40	40 / 580	5.91 / 150	5.91 / 150	7.87 / 200	7.09 / 180	5.47 / 139	5.00 / 127	5.91 / 150
2	50	40 / 580	7.87 / 200	7.87 / 200	7.87 / 200	8.58 / 218	6.30 / 160	6.00 / 152	6.50 / 165
-	65	16 / 232	-	7.87 / 200	7.87 / 200	8.98 / 228	6.81 / 173	-	7.28 / 185
3	80	40 / 580	7.87 / 200	7.87 / 200	7.87 / 200	9.25 / 235	6.81 / 173	7.50 / 191	7.87 / 200
4	100	16 / 232	9.84 / 250	9.84 / 250	9.84 / 250	11.26 / 286	9.17 / 233	8.98 / 228	8.66 / 220
-	125	16 / 232	-	9.84 / 250	9.84 / 250	11.69 / 297	9.17 / 233	-	9.84 / 250
→ 6	150	16 / 232	11.81 / 300	11.81 / 300	11.81 / 300	12.87 / 327	10.12 / 257	10.98 / 279	11.22 / 285
8	200	10 / 145	13.78 / 350	13.78 / 350	13.78 / 350	15.16 / 385	11.46 / 291	13.50 / 343	13.39 / 340
10	250	10 / 145	15.75 / 400	15.75 / 400	17.72 / 450	17.20 / 437	13.03 / 331	16.00 / 406	15.55 / 395
12	300	10 / 145	19.69 / 500	19.69 / 500	19.69 / 500	19.69 / 500	15.00 / 381	19.00 / 533	17.52 / 445
14	350	10 / 145	27.56 / 700	19.69 / 500	21.65 / 550	21.57 / 548	16.85 / 428	21.00 / 597	19.88 / 505
16	400	10 / 145	31.50 / 800	23.62 / 600	23.62 / 600	23.86 / 606	19.02 / 483	23.50 / 635	22.24 / 565
18	450	10 / 145	31.50 / 800	23.62 / 600	-	24.88 / 632	20.98 / 533	25.00 / 635	24.41 / 620
20	500	10 / 145	31.50 / 800	23.62 / 600	-	25.63 / 651	20.98 / 533	27.50 / 699	26.38 / 670
24	600	10 / 145	31.50 / 800	23.62 / 600	-	32.38 / 820	23.03 / 585	32.00 / 813	30.71 / 780
28	700	10 / 145	flanges	27.56 / 700	-	36.89 / 937	27.32 / 694	flanges	35.24 / 895
32	800	10 / 145	to AWWA:	31.50 / 800	-	41.65 / 1058	36.30 / 922	to AWWA:	39.96 / 1015
36	900	10 / 145	dimensions	35.43 / 900	-	45.83 / 1164	40.93 / 1026	dimensions	43.90 / 1115
40	1000	10 / 145	on request	39.37 / 1000	-	50.31 / 1278	44.57 / 1132	on request	48.43 / 1230
								flanges	flanges
								weight	weight
								on request	on request
								1118 / 507	

* max. pressure rating acc. DIN flanges, see column "PN (psig)"

AQUAFLUX flowmeter
Limits for pressure and temperature

Teflon® is a registered trademark of DuPont.

Liner	Flange	Nominal diameter	Pressure rating Class	S O	Max. operating pressure in psig / bar at a process temperature of ...				
					≤ 68°F / ≤ 20°C	≤ 105°F / ≤ 40°C	≤ 140°F / ≤ 60°C	≤ 176°F / ≤ 80°C	≤ 195°F / ≤ 90°C
PTFE	ANSI B 16.5	3/8" - 3/4"	150 lb	S	285 / 19.7	284 / 19.6	275 / 19.0	271 / 18.7	262 / 18.1
			300 lb	O			on request		
	DIN 2501	DN 10 - 20	PN 40	S	580 / 40	580 / 40	580 / 40	580 / 40	580 / 40
Polypropylen	ANSI B 16.5	1" - 6"	150 lb	S	285 / 19.7	284 / 19.6	275 / 19.0	271 / 18.7	262 / 18.1
			300 lb	O			on request		
	DIN 2501	DN 25 - 50, DN 80	PN 40	S	580 / 40	580 / 40	580 / 40	580 / 40	580 / 40
		DN 65, DN 100 - 150	PN 16	S	230 / 16	230 / 16	230 / 16	230 / 16	230 / 16
Hard rubber Polyurethane*	ANSI B 16.5	8"	150 lb	S	285 / 19.7	284 / 19.6	275 / 19.0	271 / 18.7	-
			300 lb	O	342 / 23.6	342 / 23.6	342 / 23.4	342 / 22.5	-
		10"	150 lb	S	285 / 19.7	284 / 19.6	275 / 19.0	271 / 18.7	-
			300 lb	O	465 / 32.1	465 / 32.1	465 / 32.1	465 / 32.1	-
		12"	150 / 300 lb	S / O	285 / 19.7	284 / 19.6	275 / 19.0	265 / 18.3	-
		14"	150 / 300 lb	S / O	258 / 17.8	258 / 17.8	255 / 17.6	245 / 16.9	-
		16"	150 / 300 lb	S / O	226 / 15.6	226 / 15.6	223 / 15.4	214 / 14.8	-
		18"	150 / 300 lb	S / O	200 / 13.8	200 / 13.8	198 / 13.7	190 / 13.1	-
		20"	150 / 300 lb	S / O	179 / 12.4	179 / 12.4	178 / 12.3	171 / 11.8	-
		22"	150 / 300 lb	S / O	162 / 11.2	162 / 11.2	162 / 11.2	155 / 10.7	-
		24"	150 / 300 lb	S / O	205 / 14.2	205 / 14.2	204 / 14.1	197 / 13.6	-
		28" - 40"	-	-			on request		
		AWWA ≥ 14"	B	S	90 / 6	90 / 6	90 / 6	90 / 6	-
			D	O	150 / 10	150 / 10	150 / 10	150 / 10	-
		DIN 2501	DN 200 - 1000	PN 10	150 / 10	150 / 10	150 / 10	150 / 10	-
			PN 16	O	230 / 16	230 / 16	230 / 16	230 / 16	-
			≥ DN 1200	PN 6 / 2.5	-	-	on request	-	-

S - Standard
O - Option

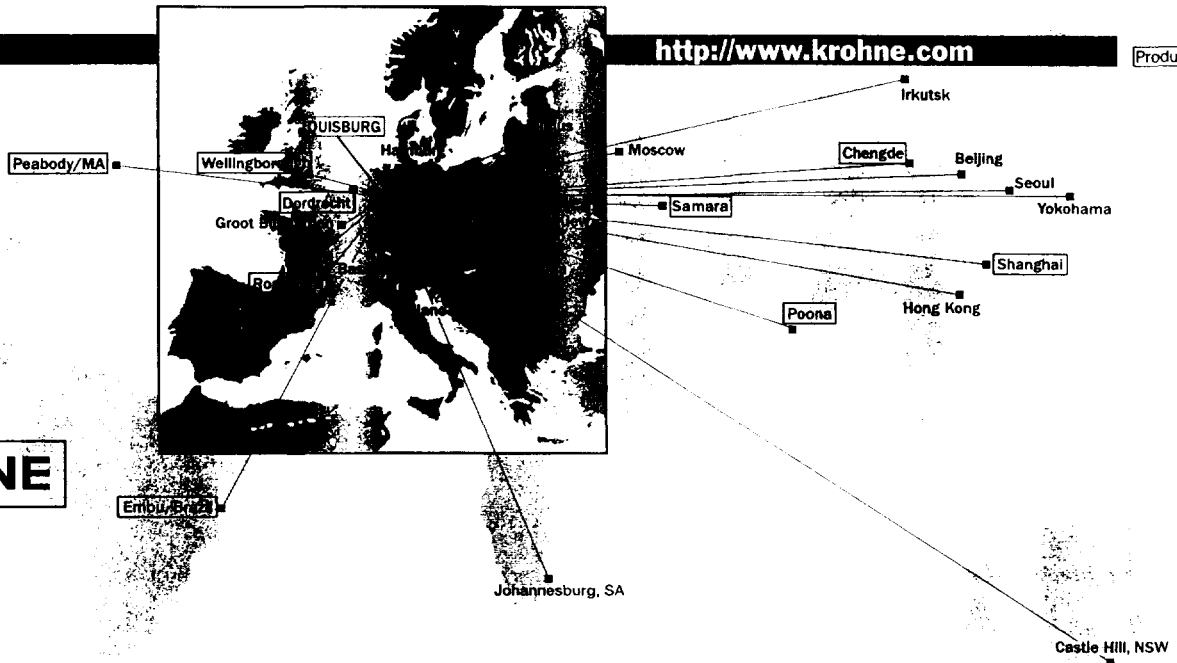
* max. temperature ≤ 158°F / ≤ 70°C
with Polyurethane liner

Vacuum load

Liner	Meter size Inches	DN mm	Min. operating pressure in psig / bar at product temperature of ...			
			≤ 68°F (≤ 20°C)	≤ 105°F (≤ 40°C)	≤ 140°F / ≤ 60°C	≤ 176°F / ≤ 80°C
PTFE	3/8" - 3/4"	DN 10 - 20	0 / 0	0 / 0	0 / 0	0 / 0
Polypropylen	1" - 6"	DN 25 - 150	3.6 / 250	3.6 / 250	5.8 / 400	5.8 / 400
Hardrubber	8" - 120"	DN 200 - 3000	3.6 / 250	3.6 / 250	5.8 / 400	5.8 / 400
	14" - 40"	DN 350 - 1000	7.3 / 500	7.3 / 500	8.7 / 600	8.7 / 600
	≥ 48"	≥ DN 1200	on request	on request	on request	on request
Polyurethane	8" - 72"	DN 200 - 1800	7.3 / 500	7.3 / 500	-	-

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French Antilles	Singapore
Greece	Slovakia
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PowerFlex[®] 700



Optimized Flexibility.

PowerFlex[®] 700 AC Drive

The PowerFlex 700 AC drive offers outstanding performance in an easy-to-use drive that users have come to expect from Rockwell Automation. This world-class performance comes in a small and competitively priced package. The PowerFlex 700 AC drive is designed to control three-phase induction motors in applications with requirements ranging from the simplest speed control to the most demanding torque control.

Excellent Performance

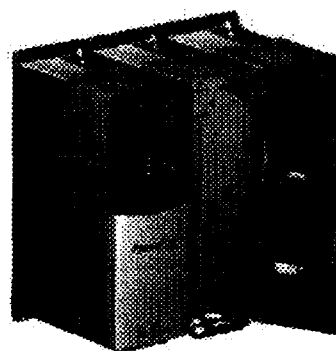
- Three control modes in one drive: Vector Control with Force Technology[™], Sensorless Vector and V/Hz control.
- Outstanding open or closed loop speed regulation for applications ranging from fans and pumps to precise control of winders.
- Excellent torque production and tight torque regulation for the most demanding applications like extruders and web processes.
- Fast update times of torque inputs are suitable for high performance applications.

Easy to Use

- Full-featured LCD Human Interface Module (HIM) with multi-line and multi-lingual display simplifies programming.
- S.M.A.R.T Start and Detailed Assisted Start-up routines in the LCD HIM allows for easy configuring and tuning of the drive.
- Pull-apart control terminal blocks allow for easy wiring and quick disconnect!
- Control cassette which houses all control, I/O and encoder options is easy to remove and interchangeable with all PowerFlex 700 drive ratings.
- Optimized global voltage settings designed to worldwide standards allow quick set-up anywhere in the world.
- Excellent PC software tools, such as DriveExplorer[™], DriveTools[™] SP and RSLogix 5000[™] make programming, configuration, monitoring and troubleshooting even easier.

Saves Space

- Innovative bookshelf design produce drives that are up to 68% smaller than other global drives.
- Bookshelf design optimizes panel space by allowing Zero Stacking[™] or side-by-side mounting of the drives. In many cases, twice as many drives can be packaged in the same panel space as competitive products.



PowerFlex 700 AC Drive
(0.37 to 110 kW; 0.5 to 150 HP)

- Save panel space and wiring time with internal communication options, internal brake transistors, integral EMC filters and integral common mode chokes.

Flexible Packaging Options

The PowerFlex 700 Standard Packaged AC Drives Program simplifies installation and start-up by allowing users to order drive packages that combine operator interface, control, communications and power options in pre-configured assemblies. Offering a number of commonly requested pre-engineered options, as well as more complex packages, Standard Packaged Drives provide a wide range of motor control options.

Communications

The Allen-Bradley PowerFlex family of drives utilizes Rockwell Automation's NetLinx[™] Open Network Architecture. This provides the common set of features and services for DeviceNet[™], ControlNet[™] and EtherNet/IP[™] networks resulting in lower total cost of ownership. Users can easily manage information from shop floor to top floor and seamlessly integrate their complete system as they control, configure and collect data.

- PowerFlex drives offer a dedicated internal communications option helping the user to cost-effectively assemble highly integrated applications that link drives to the manufacturing process through Rockwell Automation NetLinx Open Architecture based networks including: DeviceNet, ControlNet, Universal Remote I/O, and other open communications including PROFIBUS and Interbus-S.
- Status indicators for all internal communications options are visible on the cover for easy set-up and monitoring of drive communications.



**Rockwell
Automation**

Two Control Options One World Class Drive

Standard Control

The Standard Control option provides:

- Sensorless Vector Control & V/Hz Control
- DC Bus Regulation
- Slip Compensation
- Process PI Loop
- Flying Start
- 2 Analog Inputs
- 6 Digital Inputs
- 1 Analog Output
- 2 Digital Outputs

This control is great for applications such as:

- Fans
- Pumps
- Conveyors
- Mixers, Simple Extruders, and more

Vector Control

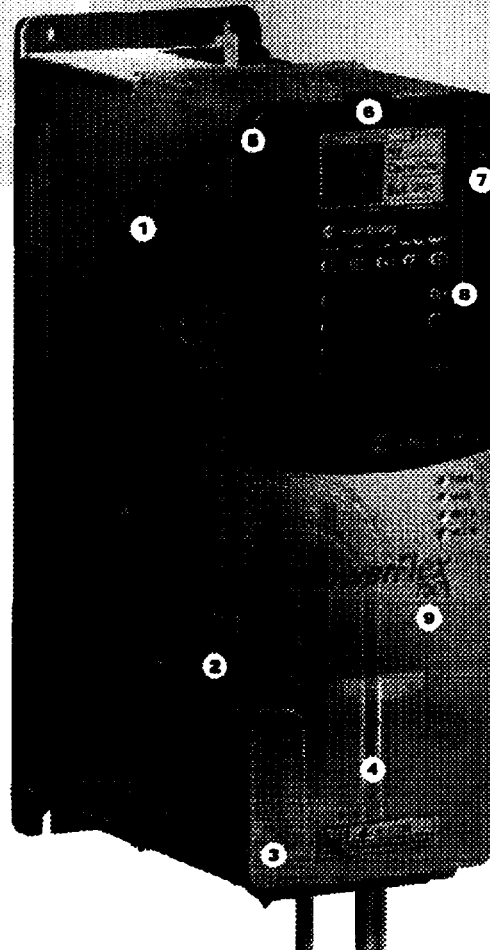
The Vector Control option includes everything a Standard Control option provides plus:

- Accurate Torque Regulation
- Precise Speed Control (open or closed loop)
- Encoder Feedback / Pulse Input (optional)
- Additional Digital and Analog Outputs (1 each)
- High Speed Analog Inputs
- Dedicated Enable Input (selectable)
- Crisp Control
- Programming Flexibility (parameter links)

This control which includes three control modes (Vector Control, Sensorless Vector and V/Hz) will easily meet most application needs. These applications include:

- Fans and Pumps
- Mixers
- Conveyors and Palletizers
- Demanding Extruders
- Web Handling / Tension Control
- Lifts / Hoists
- Centrifuges

force
TECHNOLOGY



1 Two Interchangeable Control Options

Standard Control and Vector Control are the two options available to meet a wide range of applications.

2 Encoder Interface

This Vector Control option provides an interface for a 12-volt pulse encoder.

3 Internal Common Mode Cores

No additional external cores are required to keep common mode noise from disrupting sensitive electronics. Not having to install external cores also eliminates costly labor while saving panel space.

4 Wiring

Clearly marked, conveniently placed terminal blocks provide direct access for power and control wiring. Control blocks are "pull apart" for added convenience.

5 Integral Dynamic Brake

Standard chopper transistor and available drive-mounted (or separate mounting) braking resistor provide cost-effective dynamic brake options.

6 Internal EMC Filter

Meets environmental standards without requiring additional panel space.

7 Multi-Color LED's

Status indications are visible with all covers installed to simplify diagnostics.

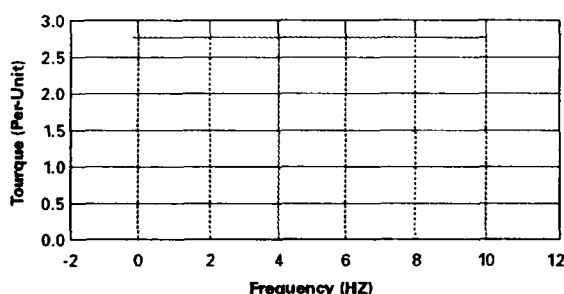
8 Human Interface Module

A flexible LCD Human Interface Module provides exceptional information display and programming ease in a multi-lingual format.

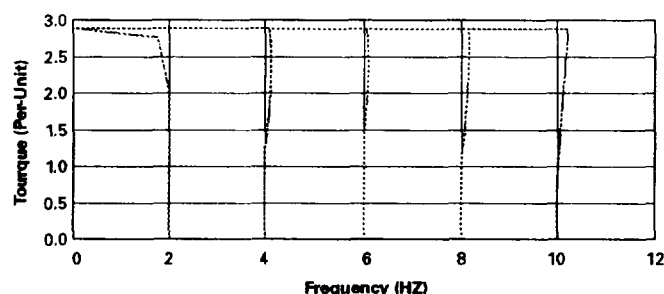
9 Internal Communications

Allows the user to integrate the drive into the manufacturing process. Status indicators for all internal communication options are visible on the cover for easy setup and monitoring of drive communications.

PowerFlex 700 with Vector Control and Encoder



PowerFlex 700 with Vector Control - Encoderless



Outstanding Vector Control

Whether it is operated with encoder feedback or without any feedback, no application is too demanding. Many applications that previously required encoder feedback can be run open loop with performance results exceeding the application's requirements.

Low Noise

The world-class PowerFlex 700 AC drive is designed to meet stringent EMC standards without adding additional filtering. All required filtering to meet CE certification is built into the drive. Not only does this save valuable panel space, but it also eliminates any of the users concerns regarding compliance.

Additionally, PowerFlex 700 drives have internal Common Mode cores on the output leads. This helps reduce common mode noise that can be problematic to other components in the system.

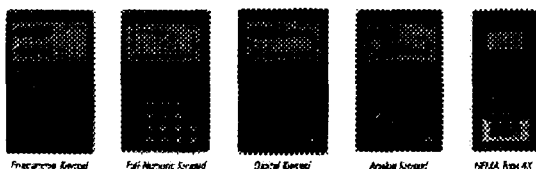
Motor Friendly

The PowerFlex 700 drive is the industry leader in protecting the motor from damage due to reflected wave phenomenon. This phenomenon is the result of voltage spikes that are caused by transistors switching into long motor cables. If these voltages exceed the insulation rating of the motor, failure will occur.

Over the past decade, Rockwell Automation has pioneered the investigation and resolution of this reflected wave phenomenon. This has resulted in proprietary and patented reflected wave reduction algorithms and hardware solutions - both internal to the drive as well as external. No other manufacturer has done more to protect induction motors from premature failures.

Human Interface Modules

The LCD Human Interface Module (HIM) supports full multi-lingual text for grouping, parameter descriptions, programming, troubleshooting and start-up. It also offers keypad options in a variety of combinations that can include digital or analog speed control, programming keys, control keys and a full numeric keypad.



Integrated Software



DriveTools™ SP Software Suite

A powerful PC based software suite, for programming, configuring, and troubleshooting.

- DriveExecutive™ – for online/offline configuration and management of drives and drive peripherals.
 - DriveObserver™ – for real-time trending of drive information.*
 - DriveExpert™ – for expert-system based troubleshooting assistance.*
- * check for availability

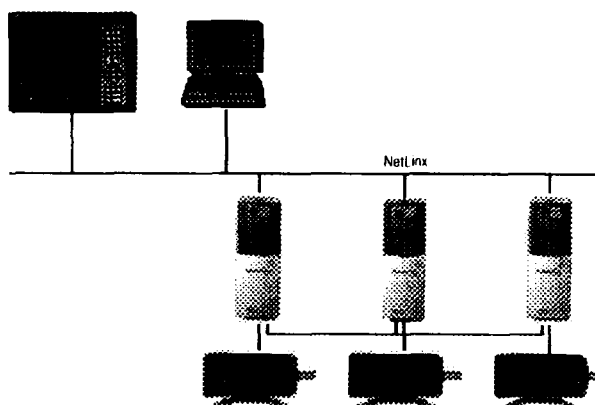


DriveExplorer™ Software

Allen-Bradley DriveExplorer software is an easy-to-use, cost effective online programming tool designed for Microsoft® Windows™ 95/98, Windows NT™ (4.0 or greater) and Windows CE (2.0 or 2.11) operating systems. It provides the user with the means to monitor and configure PowerFlex drive and communication adapter parameters.

Assured Network Connectivity

PowerFlex 700 drives and options are put through an extensive suite of tests to assure compatibility with other Allen-Bradley products from PLCs to PanelViews. Rockwell Automation offers a wide breadth of communication options along with outstanding network reliability unmatched in the industry.



Application Logic

- Process PI loop
- Flying start
- Slip compensation

- DC braking
- Line loss ride through/recovery
- Integral dynamic brake

- DC Bus Regulation
- Reflected wave reduction
- S-Curve Accel & Decel

Operator Interface

- LCD HIM places drive information in a 7-line by 21-character display that supports a variety of languages

Standards

- CSA/cUL
- UL
- C-Tick
- CE
- EMC Low Voltage EN61800-3 EN60204-1 / EN50178

Input Specifications

- 3-Phase Voltage: 200-240V $\pm 10\%$, 380-480V $\pm 10\%$, 500-600V $\pm 10\%$ / -5%
- Frequency: 47 to 63 Hz
- Logic Control Ride Through: 0.5 seconds

Output Specifications

- Voltage: Adjustable from 0V to rated motor voltage
- Frequency Range: 0-400Hz
- Instantaneous Over Current Trip: 220-300% based on drive rating

Enclosure and Ambient Operating Temperatures

- Open Type/IP20: 0Y - 50Y C (32Y - 122Y F)
- Type 1: 0Y - 40Y C (32Y - 104Y F)

Dimensions mm (in) & Ratings

Output Power		200 Volt Class Output Current			240 Volt Class Output Current			Frame Size
kW NO (HD)	HP NO (HD)	Cont. NO (HD)	1 min. NO (HD)	3 sec. NO (HD)	Cont. NO (HD)	1 min. NO (HD)	3 sec. NO (HD)	
0.37 (0.50)	0.5 (0.75)	2.5	2.5	3.0	3.2	3.2	3.5	0
0.75 (1.0)	1.0 (1.5)	4.8	4.8	7.0	4.2	4.8	6.4	0
1.5 (2.0)	2.0 (3.0)	7.8	7.8	12.0	6.5	6.5	12.0	1
2.2 (3.0)	3.0 (4.5)	11	12.1	17.0	9.8	10.8	14.4	1
3.0 (4.0)	4.0 (6.0)	17.5	18.5	26.5	15.3	16.3	22.0	2
4.0 (5.5)	5.5 (7.5)	25.3	27.8	38.0	22.0	24.2	33.0	2
5.5 (7.5)	7.5 (10.0)	32.2	36.0	50.0	28.0	30.5	42.0	2
7.5 (10.0)	10.0 (15.0)	40.3	53.1	72.5	42.0	48.2	63.0	3
11 (15)	15 (20)	60.0	84.0	117.3	62.0	85.2	110.0	3
15 (20)	20 (25)	78.2	108.0	151.3	70.0	96.0	125.0	4
22 (30)	30 (40)	113.3	158.4	220.0	104 (80)	118 (120)	175 (160)	5
30 (40)	40 (50)	132 (138)	175 (175)	250 (250)	124 (124)	142 (142)	200 (200)	5
37 (50)	50 (60)	143 (143)	175 (175)	250 (250)	143 (143)	175 (175)	250 (250)	5
45 (60)	60 (75)	177 (177)	200 (200)	280 (280)	154 (154)	180 (180)	280 (280)	6
55 (75)	75 (100)	221 (177)	243 (243)	320 (320)	190 (190)	211 (211)	300 (300)	6

Dimensions			
Frame Size	Height mm (in.)	Width mm (in.)	Depth mm (in.)
0	336 (13.23)	110 (4.33)	200 (7.87)
1	336 (13.23)	136 (5.31)	200 (7.87)
2	342.5 (13.48)	222 (8.74)	200 (7.87)
3	517.5 (20.37)	222 (8.74)	200 (7.87)
4	758.9 (29.88)	219.8 (8.65)	201.8 (7.94)
5	844.5 (33.25)	308.9 (12.16)	275.4 (10.84)
6	850 (33.46)	403.9 (15.90)	275.5 (10.85)

- Notes:
- When using the supplied junction box (100 HP drives Only), add an additional 45.1 mm (1.78 in.) to this dimension.
 - When using the supplied junction box, add an additional 128.3 mm (4.97 in.) to this dimension.

Output Power		400 Volt Class Output Current			480 Volt Class Output Current			Frame Size
kW NO (HD)	HP NO (HD)	Cont. NO (HD)	1 min. NO (HD)	3 sec. NO (HD)	Cont. NO (HD)	1 min. NO (HD)	3 sec. NO (HD)	
0.37 (0.50)	0.5 (0.75)	1.3	1.4	1.5	1.7	1.8	1.9	0
0.75 (1.0)	1.0 (1.5)	2.1	2.4	3.2	2.1	2.4	3.2	0
1.5 (2.0)	2.0 (3.0)	3.5	4.5	6.0	3.4	4.5	6.0	0
2.2 (3.0)	3.0 (4.5)	5.0	5.5	7.5	5.0	5.5	7.5	0
3.0 (4.0)	4.0 (6.0)	8.7	9.9	13.2	8.0	9.2	12.0	0
4.0 (5.5)	5.5 (7.5)	11.5	13.0	17.4	11.0	12.1	16.5	0
5.5 (7.5)	7.5 (10.0)	15.4	17.2	23.1	14.0	15.8	22.0	1
7.5 (10.0)	10.0 (15.0)	22.0	24.2	33.0	22.0	24.2	33.0	1
11 (15)	15 (20)	30.0	33.0	45.0	27.0	30.0	42.0	2
15 (20)	20 (25)	37.0	45.0	60.0	34.0	40.5	54.0	2
22 (30)	30 (40)	43.0	56.5	74.0	40.0	51.0	66.0	2
30 (40)	40 (50)	56.0	84.5	100.0	52.0	66.0	80.0	3
37 (50)	50 (60)	75.0	94.0	112.0	65.0	78.0	98.0	3
45 (60)	60 (75)	85 (72)	94 (108)	128 (144)	77 (65)	85 (98)	118 (130)	4
55 (75)	75 (100)	106 (95)	118 (128)	154 (170)	90 (77)	106 (116)	143 (154)	5
65 (90)	90 (120)	125 (96)	136 (144)	183 (168)	106 (96)	136 (144)	183 (168)	5
90 (120)	120 (150)	170 (140)	187 (170)	255 (240)	150 (125)	172 (160)	223 (200)	6
110 (150)	150 (175)	205 (170)	220 (205)	300 (240)	180 (156)	196 (204)	270 (231)	6

Output Power		800 Volt Class Output Current			690 Volt Class Output Current			Frame Size
kW NO (HD)	HP NO (HD)	Cont. NO (HD)	1 min. NO (HD)	3 sec. NO (HD)	Cont. NO (HD)	1 min. NO (HD)	3 sec. NO (HD)	
0.75 (1.0)	1.0 (1.5)	3.3	3.6	4.8	N/A	—	—	1
1.5 (2.0)	2.0 (3.0)	5.7	6.3	8.0	N/A	—	—	1
2.2 (3.0)	3.0 (4.5)	8.7	9.7	12.0	N/A	—	—	1
3.0 (4.0)	4.0 (6.0)	12.0	13.5	18.0	N/A	—	—	1
4.0 (5.5)	5.5 (7.5)	17.0	19.2	25.0	N/A	—	—	2
5.5 (7.5)	7.5 (10.0)	22.0	25.5	34.0	N/A	—	—	2
7.5 (10.0)	10.0 (15.0)	27.0	31.0	42.0	N/A	—	—	2
11 (15)	15 (20)	32.0	40.5	54.0	N/A	—	—	3
15 (20)	20 (25)	41.0	48.0	64.0	N/A	—	—	3
22 (30)	30 (40)	52.0	61.5	82.0	N/A	—	—	3
30 (40)	40 (50)	62.0	75.0	98.0	N/A	—	—	4
37 (50)	50 (60)	82.0	94.0	124.0	62 (44)	67 (60)	78 (63)	5
45 (60)	60 (75)	102.0	118.0	154.0	82 (55)	91 (75)	106 (80)	5
55 (75)	75 (100)	122.0	140.0	180.0	102 (66)	113 (85)	140 (100)	5
65 (90)	90 (120)	142.0	162.0	210.0	122 (77)	136 (100)	162 (120)	6
90 (120)	120 (150)	182.0	204.0	270.0	162 (100)	180 (135)	216 (160)	6
110 (150)	150 (175)	222.0	246.0	320.0	192 (125)	214 (160)	252 (190)	6
132 (175)	175 (225)	262.0	288.0	380.0	232 (145)	258 (190)	300 (230)	6

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Barometric Pressure Sensors

090D
091

Barometric Pressure Sensors convert absolute atmospheric pressure into a linear, proportional voltage, which may be used in any meteorological program.

Features

- Compact size
- Weatherproof enclosure
- Remote output
- Permanent calibration
- Robust construction

These sensors are inherently stable devices that do not require periodic service or routine recalibration.

Operation

The enclosure houses a solid-state pressure transducer, with linearization and amplification electronics.

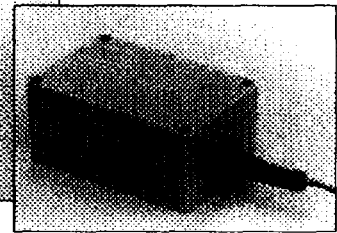
The Model 090D is housed in a heavy duty fiberglass enclosure, suitable for harsh and severe environments. A hose barb is provided to enable the connection of a 1/4" sampling tube to the outside environment.

The Model 091 is contained within a small polycarbonate enclosure, and may be mounted outside or inside a building or other enclosure. Small inlet holes allow the atmospheric pressure access to the sensing element.

The standard range of the 090D/ 091 is 26-32 in. Hg,* suitable for elevations sea level to 1500 ft. Other ranges are available.



090D



091

Specifications

Performance

Resolution:	Infinite
Temp. Operating Range:	-40°C to 65°C
Temp. Compensated Range:	-18°C to 65°C
Accuracy:	±0.04 in Hg (±1.35 mbar) or ±0.125% FS

Electrical Characteristics

Power Requirement:	11 mA @ 12 VDC, Typical
Sensor Output:	0-1 VDC, Standard 0-5 VDC, Optional

Physical Characteristics

090D	Weight:	2 lbs, 5 oz (1.05 Kg)
	Dimensions:	5.5 x 5 x 7.5 in (14 x 12 x 19 cm)
091	Weight:	8.8 oz. (250 g)
	Dimensions:	2.1 x 3.2 x 5 in (5.4 x 8.3 x 13 cm)

Ordering Information

	Specify elevation
	Specify output voltage
Cable:	#1169-xx (xx = length in feet)
	Specify length in feet

Specifications subject to change without notice.

*Conversions: 1 in. Hg = 3.3864 kPa, 1 in. Hg = 33.864 mbar, 1 in. Hg = 25.4 mm/Hg



Met One Instruments, Inc.

Corporate Sales & Service: 1600 Washington Blvd., Grants Pass, OR 97526, Phone (541) 471-7111, Fax (541) 471-7116
Distribution & Service: 3206 Main Street, Suite 106, Rowlett, TX 75088, Phone (972) 412-4747, Fax (972) 412-4716
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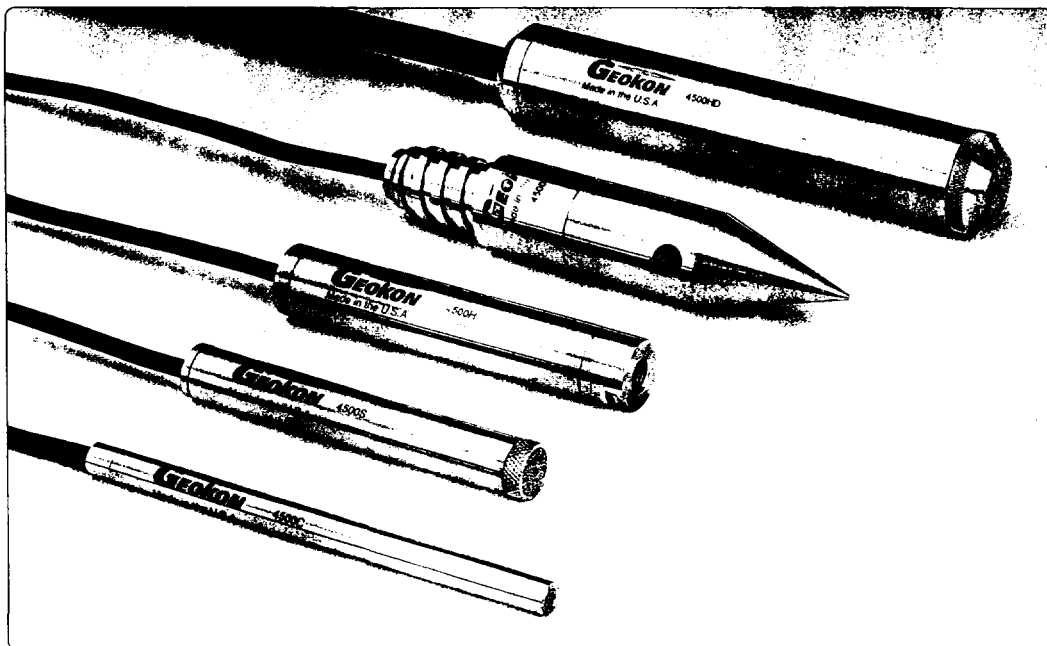
090D/091 - 7/25/97

VW Piezometers & Pressure Transducers

Applications

For the measurement of...

- Ground Water elevations
- Pore Water pressures
- Pump Tests
- Uplift Pressures in dam foundations
- Hydraulic Pressures in tanks and pipelines
- Wick Drain efficiency
- Water Pressures behind tunnel linings



• Model 4500C, 4500S, 4500H, 4500DP and 4500HD Vibrating Wire Piezometers (front to back).

Operating Principle

The transducer uses a pressure sensitive diaphragm with a vibrating wire element attached to it. The diaphragm is welded to a capsule which is evacuated and hermetically sealed. Fluid pressures acting upon the outer face of the diaphragm cause deflections of the diaphragm and changes in tension and frequency of the vibrating wire. The changing frequency is sensed and transmitted to the readout device by an electrical coil acting through the walls of the capsule.

Piezometers incorporate a porous filter stone ahead of the diaphragm, which allows the fluid to pass through but prevents soil particles from impinging directly on the diaphragm.

Advantages and Limitations

The 4500 Series Vibrating Wire Piezometers and Pressure Transducers have outstanding long-term stability and reliability, and low thermal zero shift. Cable lengths of several kilometers are no problem and the frequency output signal is not affected by changing cable resistances (caused by splicing, changes of length, terminal contact resistances, etc.), nor by penetration of moisture into the electronic circuitry.

A thermistor located in the housing permits the measurement of temperatures at the piezometer location.

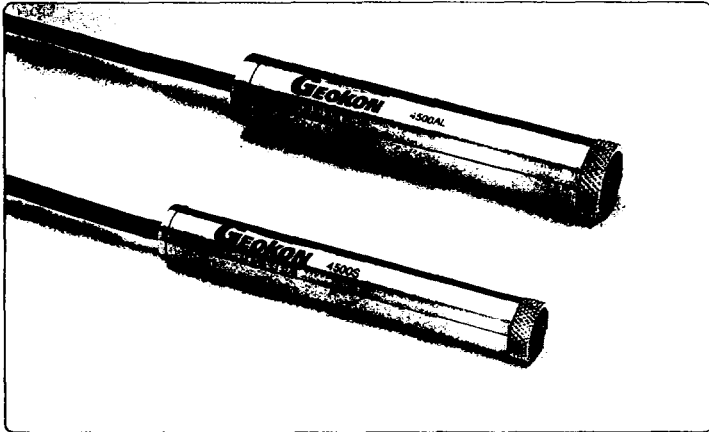
All-stainless steel or titanium construction and evacuation of the capsule guarantees a high level of corrosion resistance. Integral gas discharge tubes inside the main housing protect against lightning damage.

Standard porous filters are made from sintered 316 stainless steel. High air-entry ceramic filters are available for use in applications requiring that air be prevented from passing through the filter.

Vented versions of all models are available to provide automatic compensation for barometric pressure fluctuations. Negative pressures up to 1 Bar can be measured.

Vibrating wire pressure transducers are not suitable for the measurement of rapidly changing pressures: for these purposes Model 3400 transducers should be used.

Model 4500S, 4500AL(V) Standard Piezometers

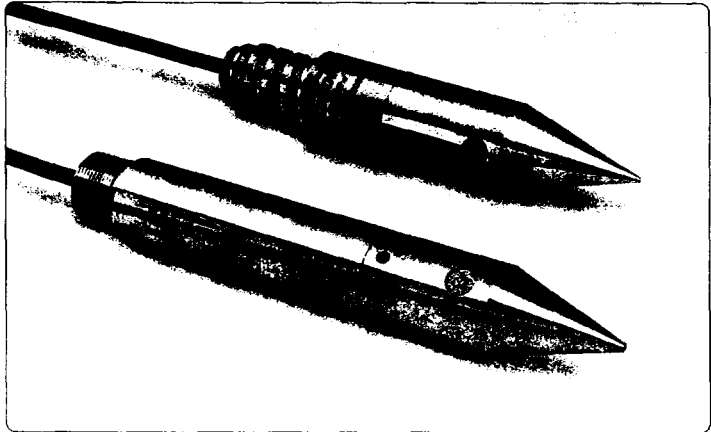


• Model 4500S (front) and Model 4500AL (rear) Standard Piezometers.

The Model 4500S Standard Piezometer is designed to measure fluid pressures such as ground water elevations and pore pressures when buried directly in embankments, fills, etc. It is also suitable for installation inside boreholes, observation wells and standard (>19 mm diameter) piezometer riser pipe.

The Model 4500AL is designed for low-pressure ranges. The vented version (Model 4500ALV) provides automatic compensation for barometric pressure changes. Thermistors are included to measure temperatures.

Model 4500DP Drive Point Piezometers

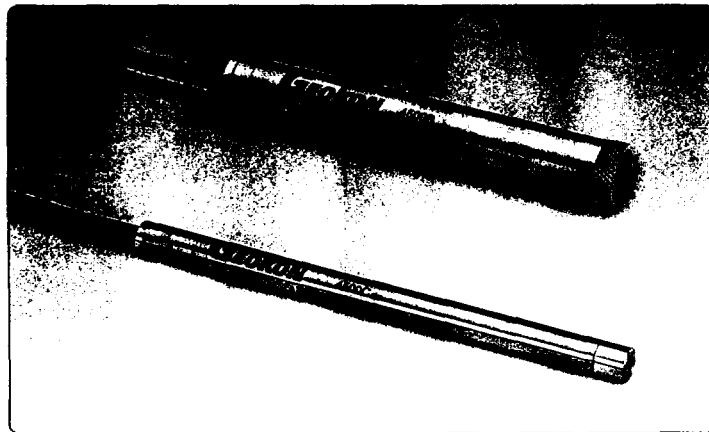


• Model 4500DP Drive Point Piezometers.

The Model 4500DP Drive Point Piezometer has the transducer located inside a housing with an EW drill rod thread and removable pointed nose cone. When threaded onto the end of EW drill rods, the unit can be pushed directly into soft ground with the signal cable located inside the drill rod. This model is ideally suited for use in soft clays and landfills. The piezometer may be recovered at the end of the job.

Models are also available that are similar in construction to the 4500DP but which use standard metric threads allowing for installation using cone penetrometer and other drill rods with adapters.

Model 4500B, 4500C Small Diameter Piezometers



• Model 4500C (front) and Model 4500B (rear) Small Diameter Piezometers.

These piezometers are designed to enable the automation of small diameter piezometer standpipes. The 4500B fits inside 19 mm pipe and the 4500C inside 12 mm pipe.

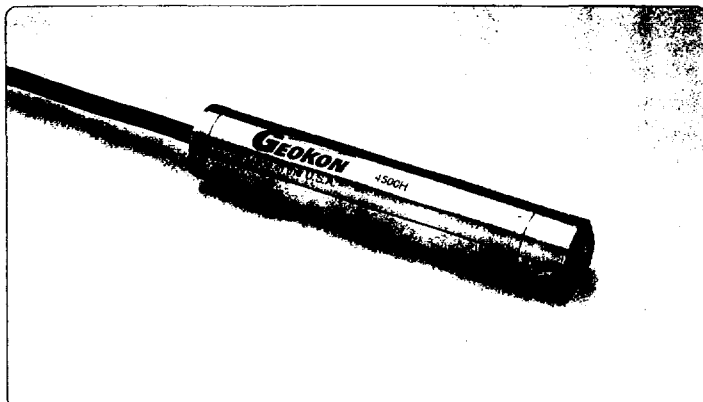
Model 4500HD Heavy Duty Piezometer



• Model 4500HD Heavy Duty Piezometer.

The Model 4500HD Heavy Duty Piezometer is designed for direct burial in fills and dam embankments. The 4500HD is used in conjunction with heavily armored cable to withstand earth movements during construction. Recommended for use in earth dams.

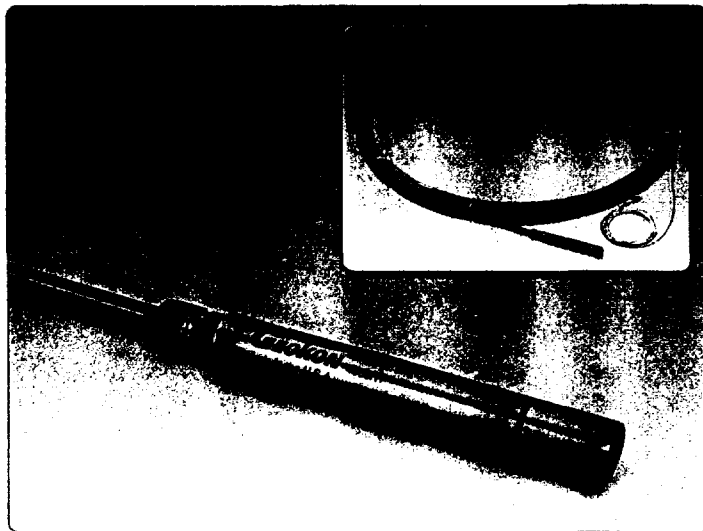
Model 4500H(H) Pressure Transducers



• Model 4500H Pressure Transducer.

The Model 4500H and 4500HH Pressure Transducers are supplied with a $\frac{1}{4}$ -18 NPT male or female pipe thread fitting to permit the transducer to be coupled directly into hydraulic or pneumatic pressure lines. Other pipe thread sizes are also available.

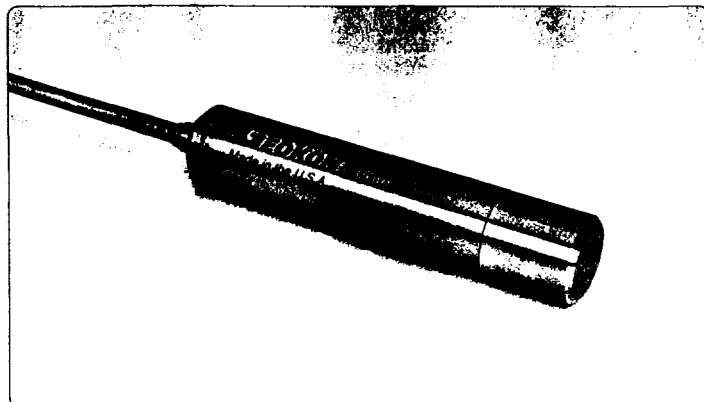
Model 4500HT High Temperature Piezometer



• Model 4500HT High Temperature Piezometer (shown coiled for shipping (inset)).

The Model 4500HT High Temperature Piezometer is designed for applications where the temperature may be as high as 230°C. Two versions are available, one for continuous use up to 200°C and one for up to 230°C. Teflon cables inside stainless steel tubing are normally supplied with these sensors.

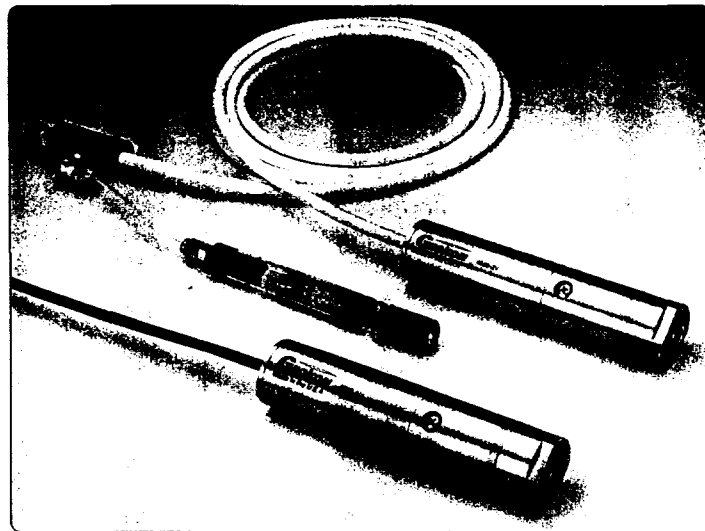
Model 4500Ti Titanium Piezometer



• Model 4500Ti Titanium Piezometer.

The Model 4500Ti is designed specifically for use in highly corrosive environments such as landfills and leach fields. Also used in critical areas where long term survivability is essential, for example, as in nuclear waste repositories and aggressive mine tailings. All exterior surfaces are made from titanium.

Model 4580 Pressure Transducer



• Model 4580 Pressure Transducer.

The Model 4580 Pressure Transducers are designed for very low fluid pressure measurements, such as groundwater elevations in wells, water levels in streams, weirs, flumes, etc. Changes in water levels of as little as 0.2 mm can be measured. Non vented types can be used as a barometer to measure atmospheric pressure changes.

Technical Specifications

Model	Standard Ranges	Over Range	Sensitivity	Accuracy	Linearity	Temperature Range ¹	Thermal Zero Shift	Diaphragm Displacement	Length x Diameter	Mass
4500S	0.35, 0.7, 1.0, 2.0, 3.0, 5.0, 7.5 MPa	2 x rated pressure	0.025% F.S. (minimum)	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	-20°C to +80°C	< 0.05% F.S./°C	< 0.001 cm ³ at F.S.	133 x 19.1 mm	0.12 kg
4500AL	70, 175 kPa	2 x rated pressure	0.025% F.S. (minimum)	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	-20°C to +80°C	< 0.05% F.S./°C	< 0.001 cm ³ at F.S.	133 x 25.4 mm	0.25 kg
4500ALV	70, 175 kPa	2 x rated pressure	0.025% F.S. (minimum)	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	-20°C to +80°C	< 0.05% F.S./°C	< 0.001 cm ³ at F.S.	133 x 25.4 mm	0.25 kg
→ 4500B	0.35, 0.7, 1.0, 2.0, 3.0, 5.0, 7.5 MPa	2 x rated pressure	0.025% F.S. (minimum)	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	-20°C to +80°C	< 0.05% F.S./°C	< 0.001 cm ³ at F.S.	133 x 17.5 mm	0.10 kg
4500C	0.35, 0.7 MPa	2 x rated pressure	0.05% F.S. (minimum)	±0.1% F.S.	< 0.5% F.S.	-20°C to +80°C	< 0.05% F.S./°C	< 0.001 cm ³ at F.S.	165 x 11 mm	0.09 kg
4500DP	0.07, 0.175, 0.35, 0.7, 1.0, 2.0, 3.0, 5.0, 7.5 MPa	2 x rated pressure	0.025% F.S. (minimum)	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	-20°C to +80°C	< 0.05% F.S./°C	< 0.001 cm ³ at F.S.	187 x 33.3 mm	0.90 kg
4500HD	0.07, 0.175, 0.35, 0.7, 1.0, 2.0, 3.0, 5.0, 7.5 MPa	2 x rated pressure	0.025% F.S. (minimum)	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	-20°C to +80°C	< 0.05% F.S./°C	< 0.001 cm ³ at F.S.	203 x 38.1 mm	1.50 kg
4500H	0.35, 0.7, 1.0, 2.0, 3.0 MPa	2 x rated pressure	0.025% F.S. (minimum)	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	-20°C to +80°C	< 0.05% F.S./°C	< 0.001 cm ³ at F.S.	140 x 25.4 mm	0.30 kg
4500HH	5.0, 7.5, 10, 25, 50, 75, 100 MPa	2 x rated pressure	0.025% F.S. (minimum)	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	-20°C to +80°C	< 0.05% F.S./°C	< 0.001 cm ³ at F.S.	143 x 25.4 mm	0.30 kg
4500HT	0.35, 0.7, 1.0, 2.0, 3.0, 5.0, 7.5, 10, 25, 50, 75, 100 MPa	2 x rated pressure	0.025% F.S. (minimum)	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	-20°C to +200°C	< 0.05% F.S./°C	< 0.001 cm ³ at F.S.	133 x 19.1 mm	0.12 kg
4500Ti	0.35, 0.7, 1.0, 2.0, 3.0, 5.0, 7.0 MPa ¹	2 x rated pressure	0.025% F.S. (minimum)	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	-20°C to +80°C	< 0.05% F.S./°C	< 0.001 cm ³ at F.S.	125 x 25.4 mm	0.19 kg
4580-1 (Sealed)	15, 35 kPa	2 x rated pressure	0.025% F.S. ²	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	-20°C to +80°C	< 0.05% F.S./°C	n/a	165 x 38 mm	0.86 kg
4580-2 (Vented)	15, 35 kPa	2 x rated pressure	0.025% F.S. ²	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	-20°C to +80°C	< 0.05% F.S./°C	n/a	165 x 38 mm	0.86 kg
4580-3	7 kPa	2 x rated pressure	0.025% F.S. ²	±0.1% F.S.	< 0.5% F.S.	-20°C to +80°C	< 0.05% F.S./°C	n/a	165 x 63.5 mm	1.72 kg
4580-4	7 kPa differential	2 x rated pressure	0.025% F.S. ²	±0.1% F.S.	< 0.5% F.S.	-20°C to +80°C	< 0.05% F.S./°C	n/a	196 x 63.5 mm	2.04 kg

Note: PSI = kPa x 0.14503, or MPa x 145.03

¹Other ranges available on request

²Depends on readout system



The World Leader in Vibrating Wire Technology™

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Geokon maintains an ongoing policy of design review and reserves the right to amend products and specifications without notice.

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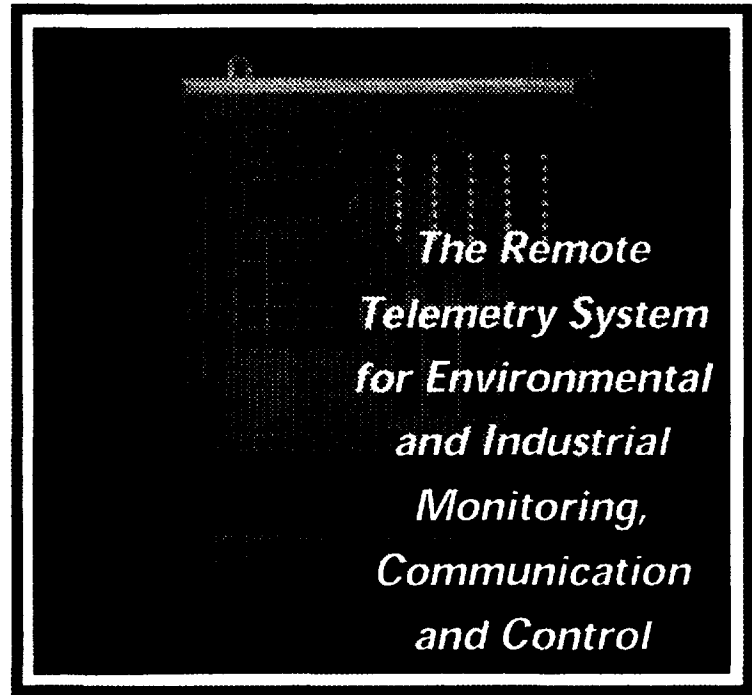
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SENSAPHONE[®] EXPRESS II

REMOTE MONITORING SYSTEM

Express II offers a comprehensive package of standard monitoring and control features, plus powerful expansion options so that you can customize the system for your specialized needs or add on as your application grows. Easy to install, program and expand, Express II may be the last monitoring and control system you need to buy.



MONITORING

Express II is equipped with 8 universal inputs, configurable as dry contact, pulse count, 0-5V or 4-20mA analog, or temperature. Easy-to-install expansion cards let you increase your monitoring capacity by an additional 32 universal input channels. Each input, whether standard installed or expanded, is fully programmable and complete with a two-color LED to locally indicate the alarm status. Express II also features built-in AC power monitoring and a built-in microphone for sound level monitoring.

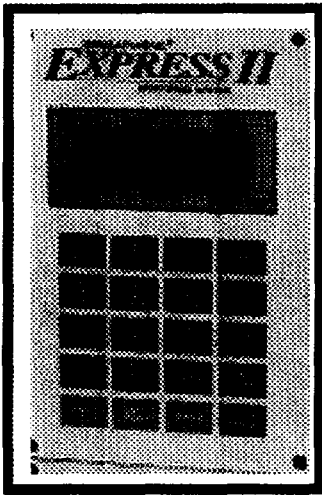
COMMUNICATIONS

The system works over standard phone lines to deliver recorded alarm messages to up to 48 phone numbers. Call progress detection ensures that the crucial alarm call goes through, with no wasted time on busy-signals or no answers. Alarm specific dialing and phone list features allow you to customize the dialout process. The digital display indicates current alarm status and phone activity. The standard local serial port allows Express II to print alarm activity to a local printer.

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MESSAGING

Digital speech technology allows you to record your voice for the dialout alarm messages and ID message. When Express II dials out for an alarm, the system recites your personalized voice message. This feature is especially useful for service personnel if you expand the input capabilities. Your creativity and Express II's flexibility enable you to have extensive monitoring capacity without confusion. All recorded voice messages are stored in nonvolatile memory.

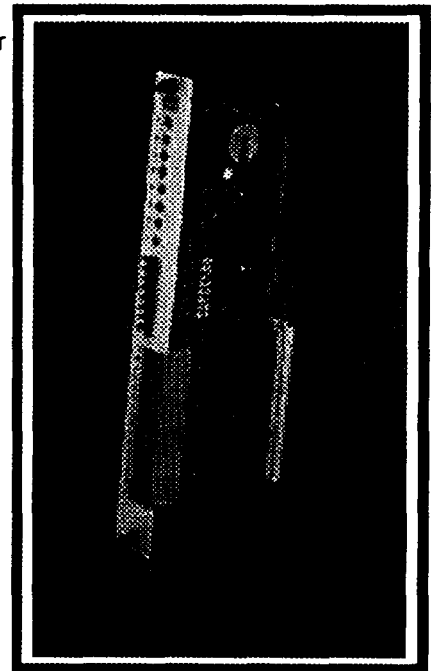


PROGRAMMABILITY

Express II is fully programmable via the local keypad or remotely by touch-tone phone. Menu-style voice guidance makes programming simple and provides easy access to all parameters, whether you are calling in or using the keypad. Nonvolatile memory ensures that your programming is not lost during a power failure or storage.

HARDWARE

Express II is equipped with one relay output that can be programmed to control automatically or manually. Expansion cards allow you to increase Express II's output capacity by up to 32 relay output channels. Express II is housed in a NEMA-4 fiberglass enclosure with 12-hour rechargeable Gel Cell battery backup.



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FEATURES

- 32 additional channels for input/output expansion
- 8 standard universally configurable inputs
- Built-in power failure and sound level monitoring
- Built-in relay output for manual or automatic switching
- Digital speech recording allows the user to record custom ID and input messages
- Complete programming access using the local keypad or via remote touch-tone phone
- Dials up to 48 user-programmable phone numbers
- Alarm specific dialing and phone lists allow the user to customize the dialing process
- Housed in a NEMA-4 fiberglass enclosure with a 12-hour Gel Cell rechargeable battery backup
- u Front panel LEDs indicate input status to on-site personnel

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SPECIFICATIONS

General:

Monitoring capacity: 8 universal input channels standard configurable as:

- Normally open dry contact
- Normally closed dry contact
- Pulse counter
- 4-20mA analog with custom look up table
- 0-5 Volt analog with custom look up table

Built in power failure monitoring

Built in sound level monitoring (smoke or fire alarm)

Output type: 1 built in relay, SPST latching 2A 250 VAC

Expansion: 32 additional channels available for input/output expansion

Programming: All parameters can be programmed from the local keypad or any remote touch-tone phone

Speech technology: ADPCM 24 kb/s

Message length: User selectable 5, 7 or 11 seconds per input channel

Message types: 1 recorded ID message

1 recorded alarm message for each input channel

Telephone numbers: Total of 48 phone numbers with 32 digits each

Allows alarm specific dialing

Multiple phone lists for day/night/weekend

Dialing format: Touch-tone, pulse, or auto-detect

Phone connector: RJ11C

Activity log: Built in RS232 port

Can automatically print alarm activity to a local printer

Local indications: Built in LCD display to show alarm dialing status

Dual-color LED indication for each input channel

Electrical:

Power requirements: 120 VAC, 60 Watts Max

Internal battery backup: 12 hour Gel Cell with built-in charger

Environmental:

Operating temperatures: 32 - 120 degrees F

Operating humidity: 0 - 90%, non-condensing

Storage temperatures: 0 - 130 degrees F

Physical:

Dimensions: 14.55" x 12.55" x 8.5"

Weight: 15 lbs.

Enclosure: NEMA-4 fiberglass with latched window cover

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